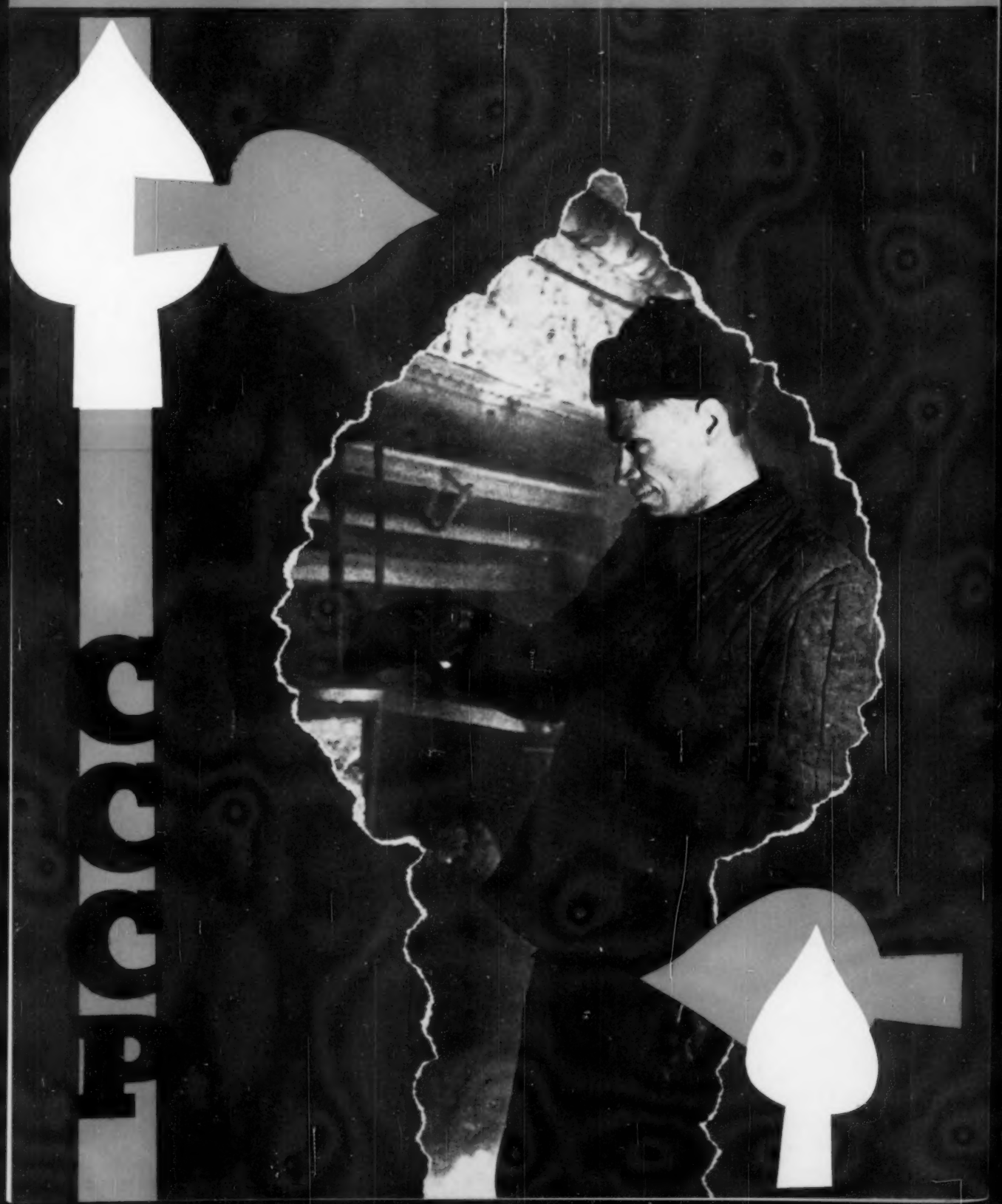
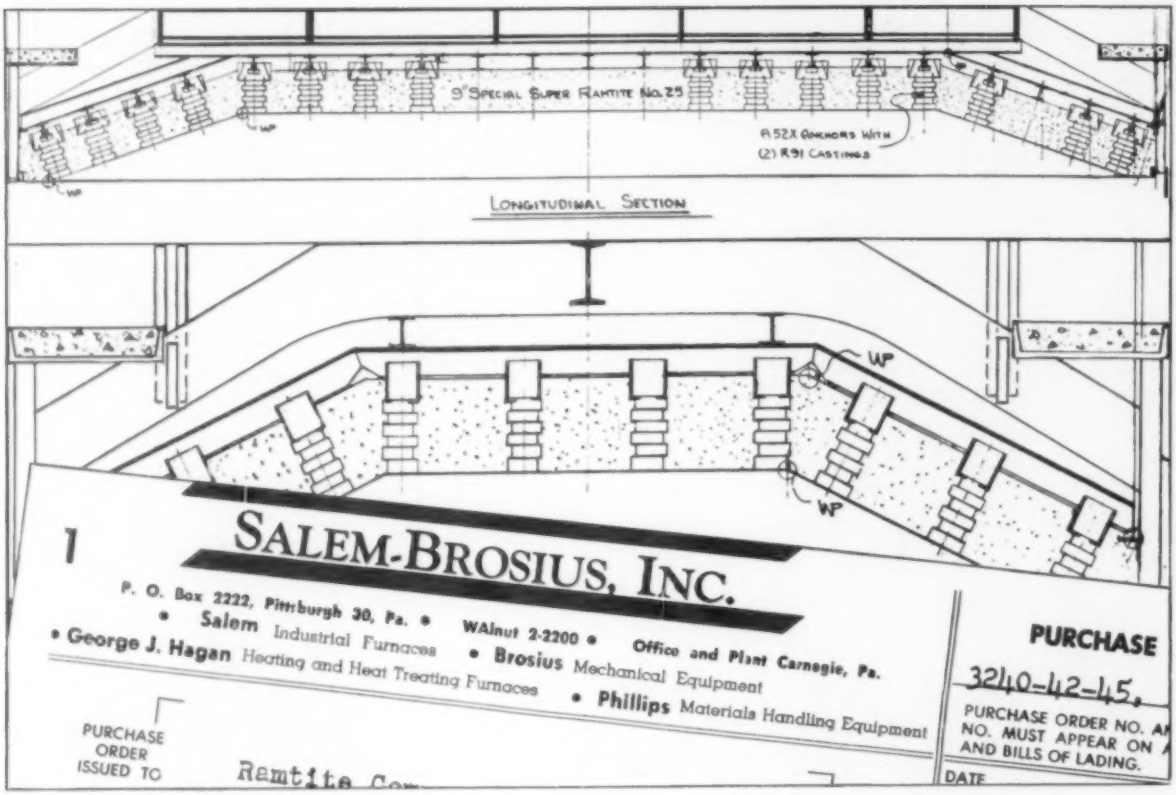
JOURNAL OF

METALS

MARCH 1958

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JOURNAL OF

METALS

VOL. 10, NO. 3 MARCH 1958

Published to provide a continuing, authoritative, and up-to-date record of technological, engineering, and economic progress in all branches of the industry by The Metallurgical Society, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 29 West 39th Street, New York 18, N. Y.

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COVER

Russian metallurgy holds the spotlight this month, and Cover Designer Naomi Lazard, through a kiosk-shaped keyhole, shows Konstantin Khabarov, expert furnaceman at the Magnitogorsk works in the Urals (picture: Sovfoto). Articles on metallurgy in the Soviet Union will be found on pp. 165-192.

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Pioneering In Industrial Research, by Kendall Birr, *Public Affairs Press,* Washington, D. C., 204 pp., $4.50, 1957.— This book, with new emphasis on basic research, tells the interesting story of the General Electric Co.'s research laboratory. Dubbed the *House of Magic* by the late Floyd Gibbons, radio announcer this title bears witness to famous scientific names; such as Charles Steinmetz and Irving Langmuir. The laboratory, which had its inception in 1902, today is allocated by unofficial estimate, $20,000,000 a year for its central research laboratory and possibly another $100,000,000 for its division laboratories.

Metal Grating Handbook, by the *Metal Grating Institute Inc.,* 1 Gateway Center, Pittsburgh 22, Pa., 28 pp., $1.00, 1957.—This new two-color handbook represents a complete product standardization in the metal grating industry and will find wide application in a variety of industries by those who buy, specify, or use metal grating and threads. The guide climaxes three years of exhaustive testing, research, coordination, and standardization by member-companies of the Metal Grating Institute Inc. The handbook is replete with schematic drawings, tables, and actual installation photos as well as complete standards and specifications.

Ideas, Inventions, Patents—How to Develop and Protect Them, by Robert A. Buckles, *John Wiley & Sons Inc.,* 275 pp., $5.75, 1957.—A simple, accurate and extremely readable statement of the principles and procedures for protection of ideas of inventions. It gives the what, why, who, when, where, and how of property protection. Fundamental principles are illustrated by specific examples and illustrations, both historic and recent, to show good and poor practices. •

Process Instruments and Controls Handbook, edited by Douglas M. Considine, *McGraw-Hill Book Co. Inc.,* 1286 pp., $19.50, 1957.—For engineers and technicians in all industries where instrumentation and automatic controls are important, this book presents an organized and thorough treatment of the operating and design fundamentals of measurement and automatic control systems used in the process fields.

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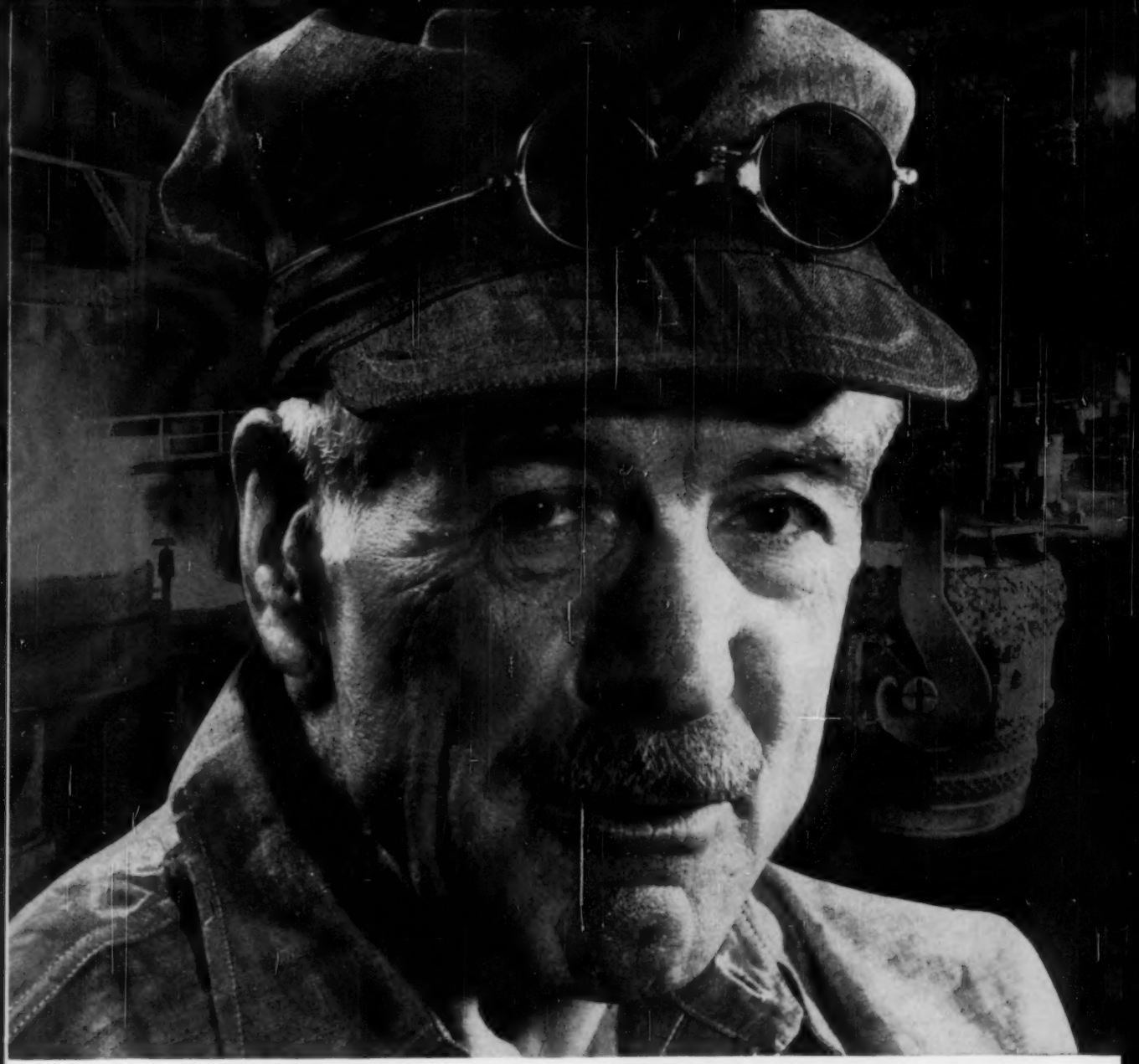

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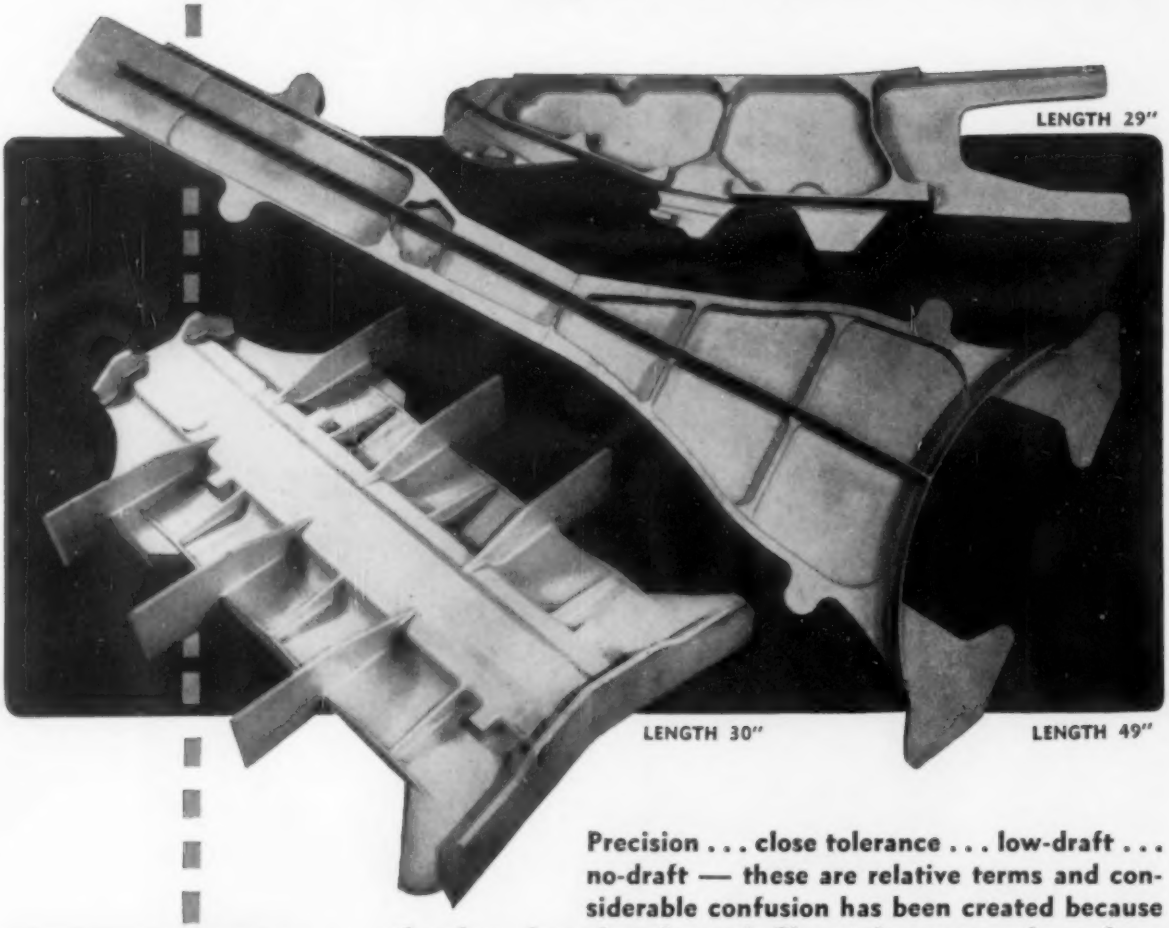

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Books

(Continued from page 152)

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Titanium—A Materials Survey, U. S. Bureau of Mines Information Circular 7791, by Jesse A. Miller, available from *Superintendent of Documents,* Washington 25, D. C., 202 pp., $1.00, 1957.—This comprehensive survey covers consumption, properties, and uses of the metal; mineralogy and geology of its ores; mining, milling, and refining techniques; metallurgical problems, economic considerations, and resources available. The survey covered data available to June 30, 1955.

Economics of American Industry, third edition, by Evan B. Alderfer and H. E. Michl, *McGraw-Hill Book Co. Inc.,* 710 pp., $7.00.—Thoroughly revised to incorporate the most recent changes, this book analyzes the economics and structure of the major American industries: steel, automobiles, chemicals, textiles, food, apparel, and others. The authors include a historical sketch of each, the nature and sources of raw materials used, technology, the leading companies, marketing and pricing policies, profits and financial aspects, and Government controls, for a complete portrayal of the industry and prevailing competition. Special attention is given to the *Big Three* of automobile production, the new competition in aluminum, and the rise of synthetic fibers in textiles, as well as to new processes of manufacture, new companies, and new products with resulting competition realignment. •

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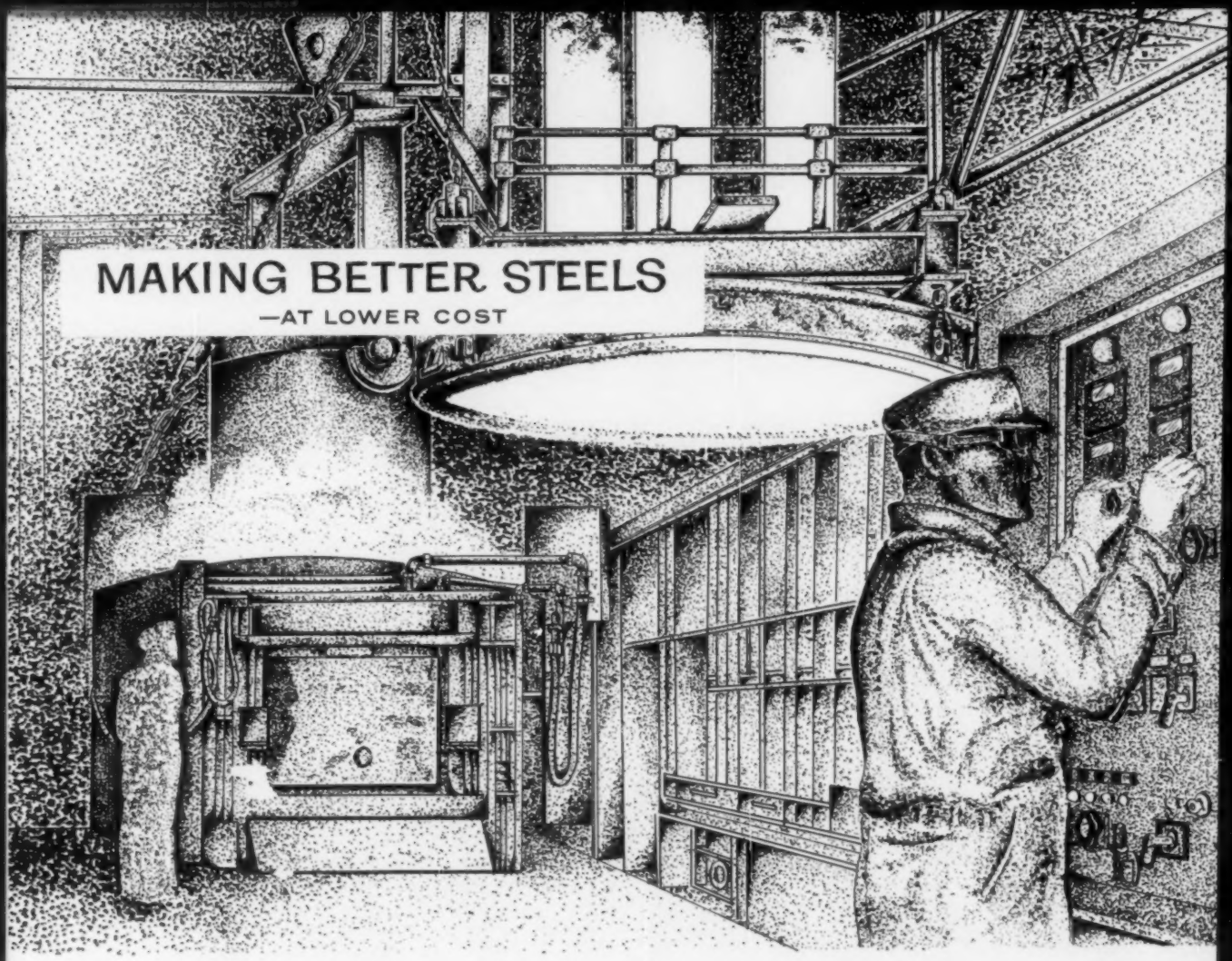

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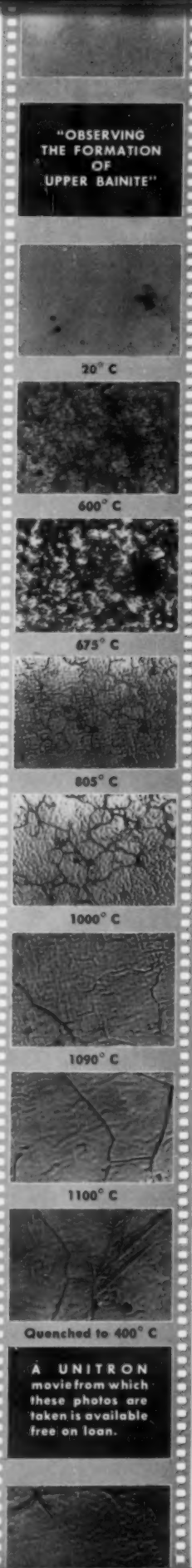

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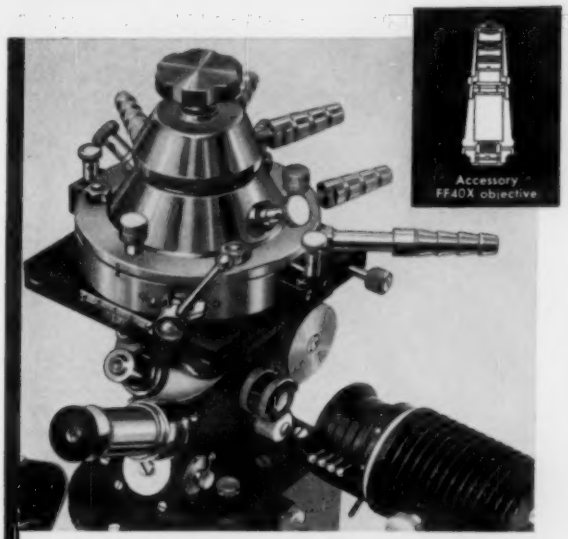

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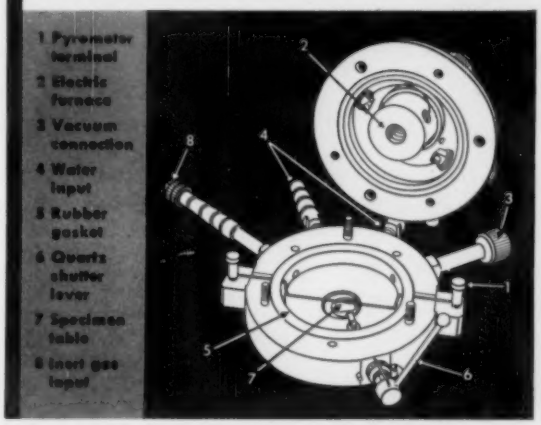

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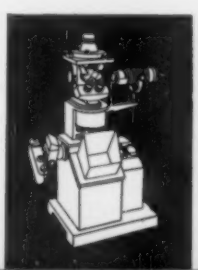

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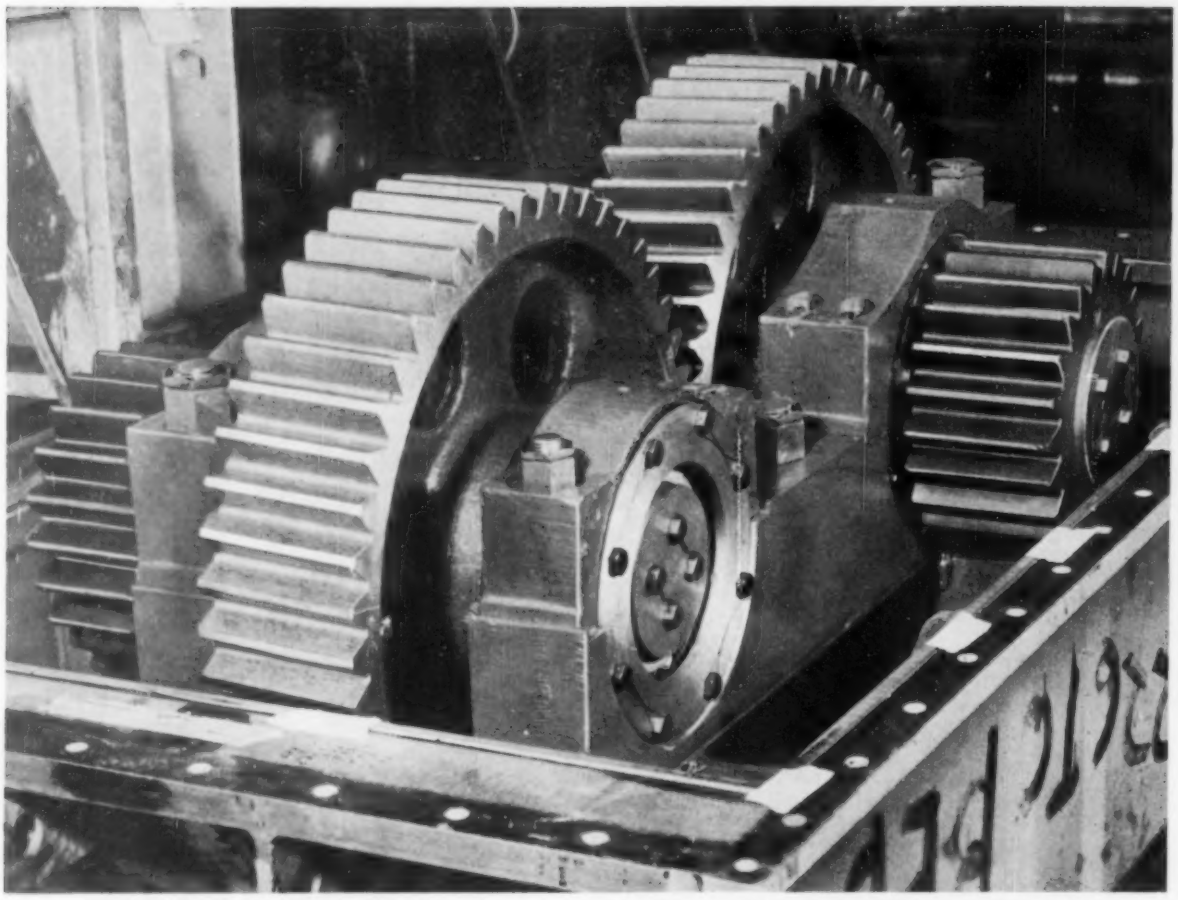

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Soviet Steel News

Reported by AIME Members Visiting the USSR

Steel Plant for Siberia

During the next five years an integrated steel plant is to be built in western Siberia at the site of a large ore deposit recently discovered, possibly Lower Angara. The plant will have five blast furnaces of 1530 cu m capacity, each capable of producing a million metric tons of pig iron per year. Six open-hearth furnaces of 500-ton capacity are also to be installed. Plant capacity may be some 3.7 million tons of rolled steel per year with a working force of 30,000 persons.

Expansion Plans for Steel

Official Soviet statistics report 1957 production of 37 million tons of pig iron, 51 million tons of crude steel, and 40 million tons of rolled products. Future expansion of the steel industry is toward the east, Asiatic USSR, where there are promising iron deposits, 75 pct of the country's coal reserves, and 80 pct of the hydroelectric power potential.

Manganese-Bearing Stainless Steels

There is reportedly no shortage of nickel at present in the USSR; however, leading Soviet metallurgists forsee a future shortage and look to manganese as a substitute for nickel as an austenite-forming element. There is, thus, considerable research going on into the use of manganese-bearing stainless steels, and an electrolytic manganese plant has been constructed in Agledzia, Georgia SSR.

Oxygen Steelmaking Processes

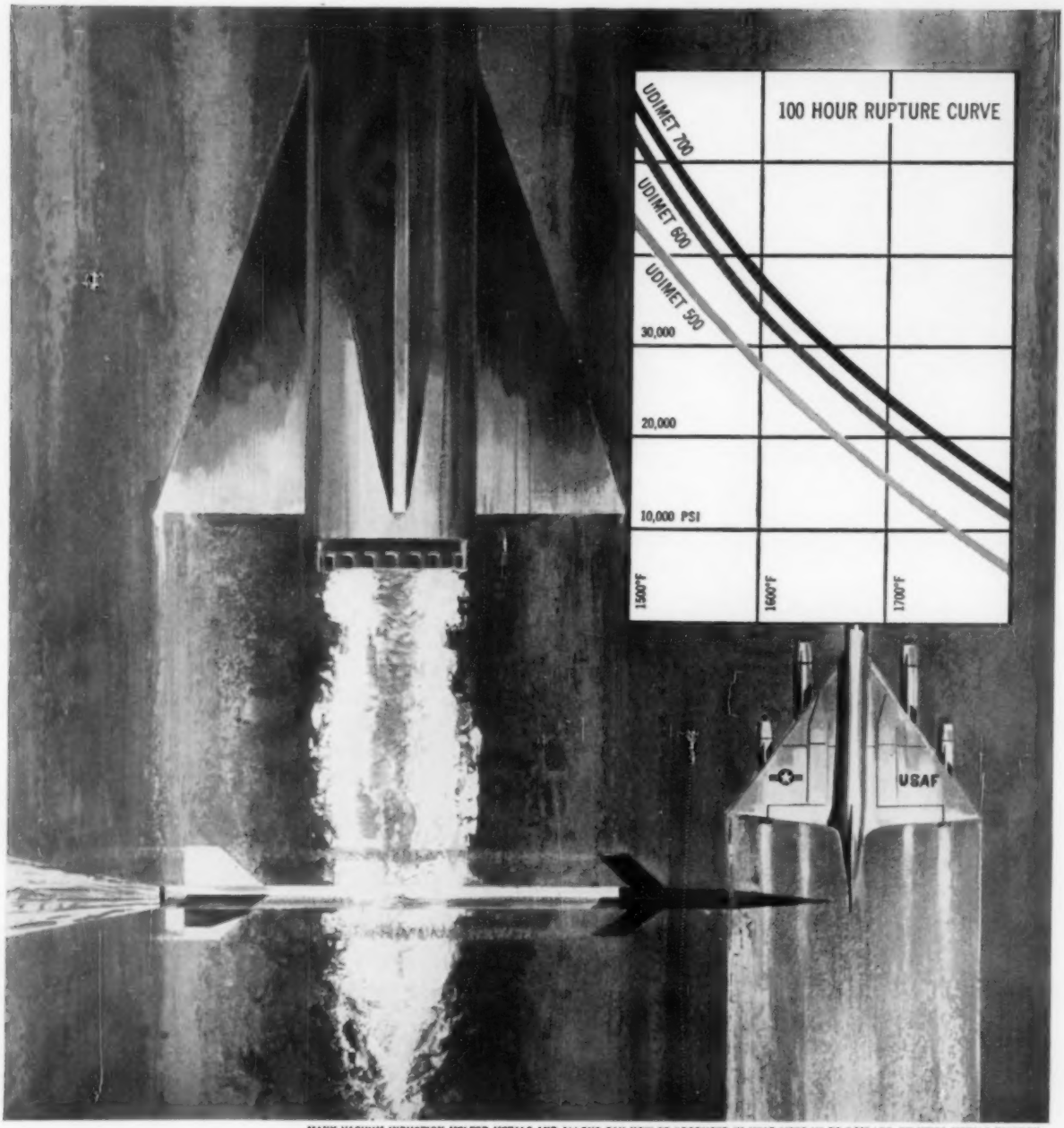
In open-hearth furnaces of 400 to 500 tons capacity, up to four roof lances of 15 mm diam are being used. The oxygen-converter process is under active study, and world developments are being closely followed. The L-D oxygen-lance converter technique is being used on a plant-scale operation in the Soviet Union. A phosphorus-removal technique has been developed wherein an 18 pct phosphorus slag is made in the converter. The Kalling rotating converter is also being studied, and an 80-ton unit is under construction.

Continuous Casting

The Soviets are reported to be continuously casting 18-8 stainless steel 150x780 mm at the Red October Works at Stalingrad. Fifty-ton ladles are used, casting into two strands. At the Stalino plant in the Donbass, a 140-ton installation to cast into four strands is being built. A third installation at Gorki casts into two strands. By 1965 it is expected that ten plants will be equipped for continuous casting.

Basic Bessemer Process Revived

The Mineral Trade Notes of the US Bureau of Mines in the October issue reports on Soviet steel expansion plans. Since many of the new iron-ore deposits that will be brought into production before 1970, particularly in the Asiatic part of the country, have a high phosphorus content, the Ministry of Ferrous Metallurgy plans to resume production of basic bessemer or thomas steel.



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EDITORIAL

The End Of Illusion

THE above picture, taken by Walter R. Hibbard, Jr., shows Morris Cohen of MIT holding a copy of the JOURNAL OF METALS in the Baikov Institute library in Moscow. This is not our edition, but rather it is a photo-offset duplication, untranslated, made by the Soviets themselves for distribution in the Soviet Union. And JOURNAL OF METALS is only one of a hundred such magazines from this and other countries that are duplicated and widely read in the USSR.

Needless to say, no similar picture could be made in an American library today with a corresponding duplication of a Soviet journal. Not that Soviet journals could not be obtained, but then what use would they be? Who could read them in Russian? Or how are they to be translated?

American metallurgists, whose recent visits to the USSR are chronicled in this issue of JOURNAL OF METALS, were astounded to find the extraordinary knowledge of American technical literature which the Soviets possess. Walter R. Hibbard, Jr., reported that "All of the Russian scientists with whom I talked had a good translation knowledge of English, and their detailed familiarity with American literature was phenomenal".

It is obviously Soviet policy to make use of technical ideas from any country, regardless of political differences, and their engineers are exposed full-blast to foreign technical developments. Such an exposure is accomplished by emphasizing foreign languages in schools, commencing with the fourth grade, and continuing through college. Engineers are required to pass a 500-word-per-hour translating examination in at least one foreign language. Foreign technical literature is available through extensive libraries, and in addition, there is a large Soviet organization for disseminating and translating scientific information.

The comparison with the US is shocking! With lack of emphasis on foreign languages in general and, until recently, even more so on Russian, few American scientists and engineers can even distinguish Russian letters, let alone absorb the contents of an article. Until a few months ago translation of Russian engineering literature was practically nonexistent, and we stood in almost complete ignorance of technical developments in the USSR. This led to the most astounding sweep of ideas. Several years ago belief was widespread that Soviet industry and research was incapable of anything but the most meager of accomplishments, while initial post-Sputnik beliefs held American technical knowhow second only to that of the Soviets!

But the picture is not completely black, and something is finally being done about the situation. For one thing translating services are being developed by libraries, engineering societies, and private agencies. For another thing, visits to the Soviet Union of American engineers are increasing our knowledge of the Soviet efforts. However, such efforts to be extended must be stimulated by a continuing demand. If research administrators, contractors, librarians, and government officials are presented with a sustained demand for translations of Soviet technical literature, it will be produced.

The present problem serves to point up a basic weakness in American education. In the long run America must face the task of seeing to it that its educated have at least a reading knowledge of one or more foreign languages. In this context we refer to Russian, but Germany and France as well as other countries are also going ahead in the technical field, and our knowledge of these foreign developments is impaired by our inability to read scientific reports in their original language.

The door has been opened. Let us increase the translation of Russian technical literature and augment the visits of American engineers to the USSR and in the longer run increase our reading knowledge of foreign languages.

Not only will these means keep us abreast of scientific developments on the opposite side of the Iron Curtain, but perhaps they may also tend to lessen the distrust which divides us today.

F. Weston Starratt and James J. Burke

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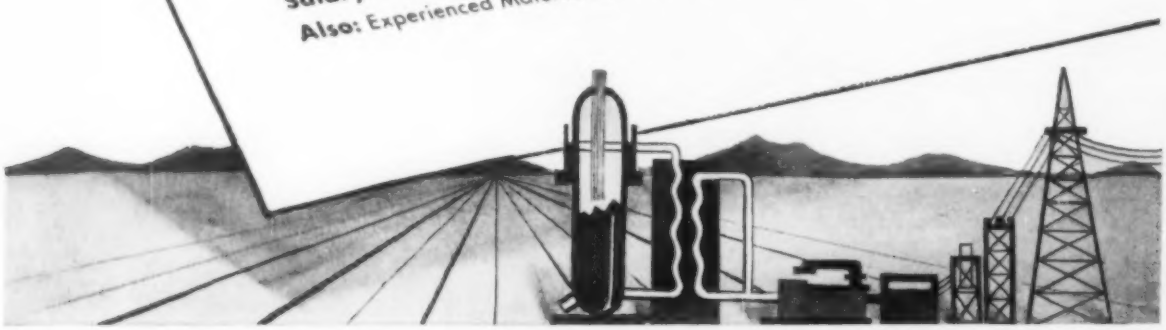

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THE AMERICAN-SOVIET METALLURGICAL EXCHANGE

IT began in the autumn of 1956 when Professor A. M. Samarin of the Baikov Institute of Metallurgy of the Academy of Sciences of the USSR accepted an invitation to attend the titanium conference at New York University. In turn Professor John P. Nielsen of New York University was invited to visit metallurgical laboratories in the Soviet Union.

This led to an invitation to Professors Samarin and Karasev to attend New York University's conference on Vacuum Metallurgy at which they presented two papers. Involved in this second exchange was an invitation to Professors John Chipman and Nicholas J. Grant of Massachusetts Institute of Technology to visit educational institutions, research laboratories, and steel plants in Moscow, Leningrad, Sverdlovsk, and Magnitogorsk.

This was followed by a third round of exchanges late in 1957 at which time metallurgical delegations were organized by the Moscow Steel Institute and New York University. The American delegation was led by Professor John P. Nielsen of New York University, and included AIME members Dennis J. Carney, Morris Cohen, Claus G. Goetzel, J. Donald Hanawalt, Walter R. Hibbard, Jr., Thomas W. Lippert, Leslie L. Seigle, Joseph W. Spretnak, and David Swan.

The itinerary for the American metallurgists was as follows:

In Moscow:
1) Moscow Steel Institute
2) Central Scientific Research Institute for Ferrous Metallurgy
3) Central Scientific Research Institute for Machine Building and Technology
4) Moscow Institute for Nonferrous Metal and Gold, named after Kalinin
5) Institute for Metallurgy, named after Baikov

In Leningrad:
1) Leningrad Polytechnic Institute
2) All Union Aluminum and Magnesium Institute
3) Leningrad Mining Institute

In Zaporezhe:
1) Dnieperprestoye Steel Works
2) Zaporezhe Ferro-Alloys Plant

In Kiev:
1) Metal Physics Institute
2) Kiev Polytechnique Institute
3) Institute of Chemistry

In Magnitogorsk:
1) Magnitogorsk Combinat

In Sverdlovsk:
1) Institute of the Physics of Metals
2) Sverdlovsk Polytechnic Institute

The Soviet delegation in their visit to the United States in November 1957 participated in the World Metallurgical Congress in Chicago and visited research establishments, universities, and steel plants. Among others, the Soviet delegation included Academician G. V. Kurdjumov, Professor I. N. Kidin, P. I. Poluhkin, I. Belyaev, and A. M. Dimov.

The JOURNAL OF METALS is proud to be able to present in this issue the impressions which several of the American metallurgists gained of Soviet technical education, research, and industrial development. Also included are two papers by leading Soviet metallurgists.

by John P. Nielsen

A LETTER FROM SVERDLOVSK

Impressions of the Soviet Union and its metallurgical development.

Town square of Sverdlovsk, some 1000 miles east of Moscow, just over the divide into Asia. Photo by John Chipman of MIT.

SVERDLOVSK is a good city for a letter to the States. We are 1000 miles east of Moscow, in Siberia, in fact, a few miles on the Asiatic side of the Soviet Union in the Central Urals. The city is a quiet one, although it has perhaps a population of 700,000. A few minutes ago I looked out the window and let myself be captured into watching the activity of the principal intersection of the city. There is a slight resemblance to a New England town, with the white church in the center. The church building now serves as a bus station, the cross replaced by a red star. A horse and wagon pulled up to the front of the station to unload some trunks. You felt that a desecration had taken place, not so much because a church building was now serving only a utilitarian function, but because it was a time of slush and mud in the streets, and considerable mud was being tracked on the entrance steps and inside.

Deviation from itinerary proves difficult

Our itinerary in the Soviet Union was not too firmly established before leaving the United States, and the first order of business upon arrival was to get this straightened out. I learned that in discussing the itinerary with our hosts, no commitments could be made without their checking with a high level office dealing with scientific visitors. Our hosts had a full itinerary prepared for us, but it included a number of show places which would not interest metallurgists, such as the atomic power plant near Moscow and an automobile plant. Furthermore, some omissions had been made as to particular laboratories we wished to visit. All in all, the itinerary was not too bad, as it included a number of good metallurgical laboratories. To get changes, however, turned out to be a formidable task. Also, especially in Kiev and Magnitogorsk, there was a tendency to stretch out the cultural and sightseeing programs at the expense of the laboratory visits.

In most places that we visited, there seemed to be a genuine desire to have us learn something during the visit. In some instances the director appeared quite willing to answer most questions about his organization and planning. In speaking with the research people themselves, we usually found the universal desire to talk and exchange ideas about the research they were doing. Certain questions, however, seemed to find no answers. Questions on production volume and applications were generally fended off. I got into a little controversy when I asked about some production figures. I had asked a prominent aluminum metallurgist what the Soviet

JOHN P. NIELSEN is Chairman, Dept. of Metallurgy, New York University.

Departure from New York for the USSR of a group of US metallurgists late in 1957. From left to right AIME members Joseph Spretnak, Denis Carney, Arnold Pressman (of the Russian language department of New York University), Morris Cohen, Thomas Lippert, John Nielsen (group leader), J. D. Hanawalt, Leslie Seigle, Claus Goetzel, David Swan, and Walter Hibbard. Photo courtesy Sylvania Electric Products, Inc.

aluminum production figures were. He replied that he was a professor and, therefore, was not interested in production figures. Furthermore, he added that US does not publish its nonferrous production figures. I said that this of course was not so, as I use well known textbooks in my own courses in the University, giving figures for aluminum, zinc, copper, lead, tin, etc. To this he replied, "What about your beryllium figures?" Thus, the balance was maintained—we do not publish our beryllium production figures, and the Soviet Union does not publish its nonferrous figures.

Some other odd things seemed to be avoided in discussion. One metallurgist (we learned from several people) was a director of a rather important institute. One of our delegates met him by chance after one of his lectures, and on asking where he was employed, he said he was merely a teacher in an aviation trade school. After several varieties of *putting-off* techniques had been used on us, I realized that we were welcome to learn so much and no more, and that a fairly unified front of resistance was met if we tried to learn more—all fair enough to be sure and, actually not too different from the relationship between two friendly but intense industrial competitors in the US.

Institutes prove up to date

One of the best metallurgical laboratories is the Institute for Metallurgy, where Academician I. P. Bardin is director, and Professor A. M. Samarin is deputy director. Academician Bardin, Vice President of the Soviet Academy of Sciences is an elderly, soft spoken, and pleasant gentleman, who is known as the dean of Soviet metallurgists. Professor Samarin is an exceptionally well-informed metallurgist with a fascinating personality.

We saw a microprobe analyzer that had been built apparently at the same time that Castaing designed and built his first unit in France. Hall effect measurements on liquid alloys appeared to be nicely carried out. Professor Oding is specializing in microstrain research in metals, and at the present is almost the sole proponent of the dislocation theory in the Soviet Union. Professor Ageev is head of research on the crystallography of metals.

Several of the American delegates went to the excellent and large ferrous metallurgical laboratory where Academician Kurdjumov heads the Institute for Metal Physics and Metallography. Academician Kurdjumov is a delightful personality, and he has obviously influenced much of Soviet physical metallurgy advances.

Our delegates found the Moscow Steel Institute a vast, although not the largest, school of metallurgy, with 2500 students following various ferrous metallurgy curricula. Director Kidin of the institute was our host, and we found him attentive to our needs and quite willing to carry out the agreements on the exchange to a successful conclusion.

In Sverdlovsk, Walter Hibbard, Morris Cohen, and I were met by a Moscow Steel Institute representative, Grigorian, who had preceded us two days previously to make preparations, and by a group of Uralian metallurgists from the Institute of Metal Physics. Our host was to be Professor Vonsofsky, of Polish extraction, and a student of Joffé, who turned out to be charming, delightful, and brilliant in his field of metal physics—and who spoke English rather well.

The next day we visited the Institute for Metal Physics and found that preparations for our visit had been well made. Schedules were handed to us, and as elsewhere, there was evident a desire for us to see and learn a fair amount of what they were doing. In almost all cases the description of work was confined to already published work two or three

years old. Dr. Joffé had been the prime mover in initiating this institute, and, as we had gotten used to by now, Academician Bardin had, until just recently, been the director. This Institute does some creditable work in high pressure (up to 30,000 atmospheres), low temperature, magnetism, and steel heat treatment. One of the delights of our Sverdlovsk visit was in meeting Dr. V. I. Drozhena, one of the many women metal physicists and physical metallurgists in the Soviet Union. One could see that Dr. Drozhena had a Madame Currie-like intensity for things scientific, and there was an old world Slavic beauty about her. Like most Soviet women, her hair was uncut, no lipstick used, and her dress and shoes were what might be called *sensible* in the States.

In Sverdlovsk, as elsewhere, metallurgy was a popular curriculum. In Moscow there are about 6000 to 7000 students studying metallurgy, and in Sverdlovsk are to be found another 1500.

Random impressions of Soviet life

We got to see a bit of various sides of Russian life. A student we met was majoring in Bengalese at some kind of institute for foreign affairs. His interest in Bengalese came about primarily because his stipend in college was about 50 pct higher than that for other specializations. He said he worked hard on his studies and was writing a thesis on the living conditions of Bengalese workers—all from library data. His opportunity to speak Bengalese was scanty, as only one family in Moscow spoke the language.

One lad showed so much desire to meet and chat with us that we thought he might be anti-communist. But no, as a matter of fact he was a member of the Comsomol, the communist youth organization. When asked why he belonged to the Comsomol, he said that it would help him become a communist party member after he finished school. We asked why he wanted to become a party member, and he replied simply that it is a sensible ambition, and a good goal to strive for.

The Soviet citizen can buy most things he may want in Moscow and the bigger cities, although there is apparently a frequent scarcity of items, and the variety is small. The price he pays for the everyday needs of food, clothing and furniture, if one considers quality and income, is about ten times that in the U.S. For example, a pound of beef chuck comes to about 18 rubles and the average wage earner earns 4½ rubles per hour. This is, of course, only a rule of thumb. Books, apartment rents, and haircuts are relatively inexpensive, while clothes, candy, cigarettes, and shoes are expensive. Almost everything is of Communist manufacture and in American stores would be classified as sturdy and plain.

The prominent squares of Moscow are spacious and the boulevards or avenues are wide, and clean. Five-ton trucks seem to be as numerous as cars. The cars, incidentally, are all Soviet makes, and rarely is there seen a foreign car. They resemble Chevrolets, Buicks, and Packards of fifteen years ago, although duplicates of 1951 Fords are now coming off Soviet assembly lines. Traffic is light in Moscow, about what it is in American cities about 7:00 am on a Sunday morning. Away from Moscow, traffic thins considerably, with trucks out-numbering the cars.

In Moscow, there was some interest to meet us on the part of Russians in restaurants and in the street. Boys in front of the hotel would surround us to ask for souvenirs—there was no begging, just requests for gum or American coins. Actually, the only indifference was met in the small towns, or cities away from Moscow. The reason for this may possibly be that the people are still cautious in places like Sverdlovsk and Magnitogorsk, whereas in Moscow, the caution has given way to franker expressions of curiosity. I might add that there was practically no rudeness met anywhere, and where a brief encounter was made it was always a pleasant one. One wonders whether a Russian would be able to say the same on a similar United States tour.

Academician Kurdjumov, a member of the Academy of Science of the USSR, professor in the Moscow Steel Institute, as well as head of the Metal Physics Institute in the Central Scientific Institute for Ferrous Metallurgy . . . was host to some of the US metallurgists visiting the USSR. Photo by J. H. Hollomon of General Electric Research Laboratories.

Two leading Soviet metallurgists greeted the American delegation. At left is Professor A. M. Samarin, member of the Academy of Science, Deputy Director of the Institute for Metallurgy, and a professor at the Moscow Steel Institute. At right is Academician I. P. Bardin, Vice President of the Academy of Science, Director of the Institute for Metallurgy, and Director of the Central Scientific Institute for Ferrous Metallurgy.

SOVIET TECHNICAL EDUCATION

THE JOURNAL OF METALS *surveys Soviet technical education from three Massachusetts Institute of Technology professors of metallurgy who recently visited the USSR. Professors John Chipman and Nicholas Grant made the trip in June 1957, while professor Morris Cohen went later in the year with the group of metallurgists led by Professor John Nielsen of New York University. David Swan and Walter R. Hibbard, Jr., research specialists for Linde Co., Div. of Union Carbide, and General Electric respectively, were also among the latter group and have contributed to this exclusive survey.*

On the basis of their talks with leading Soviet professors and research metallurgists, as well as their inspections of educational facilities, professors Chipman and Grant of MIT commence this survey with "Metallurgical Education in the USSR" giving particular emphasis to the Leningrad Polytechnique Institute and the Moscow Institute of Ferrous Metallurgy.

Metallurgical Education in the USSR

by John Chipman and Nicholas J. Grant

STUDENTS entering schools of metallurgy appear to have had a very good primary school preparation. They enter at the age of 17 to 18 after 10 years in the Russian school system. For the most part, they have had about three years each of chemistry and physics and, of course, have had mathematics throughout their school career. They have all studied at least one language, perhaps 80 pct of them have had English with the remainder being scattered between German, French, and other languages.

The first three years at the institute are broadly educational. Students study mathematics, chemistry, physics, statics and dynamics, strength of materials, and continue to study a language. The arts and humanities are not emphasized. The student takes the history of the Communist party for one year, political economy for two years, and philosophy for one year.

The last two years are highly specialized. A student chooses not only between ferrous and nonferrous metallurgy, but also he may further elect to major in iron production, steel production, electric furnaces, or rolling mills. His field of specialization then becomes his field of work during summers and the field for his thesis. He is, of course, placed in this field when he has received his Diploma.

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The institutes of metallurgy are all crowded and have to turn away students who would like to enter. Applications usually exceed openings by three or five to one. Entrance is through competitive examinations. The study load appears to be heavy. Contact hours are estimated at 6 per day for a 5½ day week. This requires additional study beyond the time mentioned; the amount of home-work, however, is less than in our schools.

Students in all the institutes receive a stipend, unless their families have an income of 600 rubles per month per member, in which case the family is expected to take care of the student. The stipend for the first year is 300 to 400 rubles per month, the former figure being a bare subsistence level. Rooms in the dormitory are very cheap, and food in the cafeterias costs the students from 10 to 15 rubles per day. The stipend is increased from 40 to 50 rubles each year. By the time the fifth year comes along, it amounts to about 600 rubles per month; for graduate students the stipend is 1000 rubles per month. About 80 pct of the students receive stipends. A graduate enters industry at 800 to 1000 rubles and may be promoted to 5000 rubles in a few years.

Leningrad Polytechnic Institute

At this institute there are nine faculties including metallurgy, machine tools, power machinery, electromechanical engineering, and economics. There

Leningrad Polytechnic Institute, founded in 1902, has 11,000 students in nine departments: mechanics, power, hydraulics, metallurgy, electrical engineering, physics, radio technology, economic engineering, and evening school.

are 11,000 students and 1000 teachers, of which 100 are professors. The Institute is 60 years old and has had many famous metallurgists on its faculty, including Baikov.

The School of Metallurgy has 1500 students in a five and one-half year curriculum and about 220 graduates each year with the *Diploma* in metallurgy. The following table lists the number of contact hours and the semesters in which various subjects are taken. There are two semesters per year, so semester 6, for example, would mean second term, third year.

Subject	Contact Hours	Semester
Mathematics	360	1, 2, 3
Physics	304	1, 2, 3, 4
Theoretical Mechanics	200	2, 3, 4
General Chemistry	170	1, 2
Foreign Language (English or German required)	136	1, 2, 3, 4
History of Party, Political Economics, Philosophy	390	1-8, incl.
Analytical Chemistry	240	3, 4, 5
Mineralogy, Crystallography	68	3, 4
Physical Chemistry 100 hr lecture, 82 hr lab.	182	5, 6
Descriptive Geometry and Mechanical Drawing	172	1, 2
Testing Materials	170	3, 4
Machine Components	178	3, 4, 5
Hydraulics	56	5
Blowing and Pneumatic Engines	56	6
Electric Technique	142	5, 6
Theory of Metallurgical Processes	192	5, 6
Metallurgical Furnaces and Automation	180	5, 6, 7
Metallography and Testing	180	5, 6, 7

Physical education and work shop training are also required.

It should be noted that the above listing shows what takes place during the first three years, and this is common apparently for all seven fields included in metallurgy. Subsequently, in the fourth, fifth, and fifth and a half years, specialization becomes the vogue.

There are seven fields of metallurgical specialization, which are as follows: 1) Ferrous metallurgy, 2) Non-ferrous metallurgy, 3) Casting and foundry, 4) Heat treatment, 5) Cold and hot working of metals, 6) Welding, and 7) Furnace design.

The following additional subjects are for those who specialize in ferrous metallurgy:

Subject	Contact Hours	Semester
Thermal Techniques and Thermodynamics	70	7, 8
Building Construction	42	7
Metallurgy of Non-Ferrous Metals	42	9
Casting	56	9
Plastic Working of Metals	70	9
Heat Treatment	48	10
Metallugry of Cast Iron	238	7, 8, 9
Metallurgy of Steel	234	8, 9, 10
Electric Melting of Ferrous Metals	186	8, 9, 10
Economics of Industry, Planning, Organizing, and Building	104	9, 10
Safety and Fire Protection	36	10

There is further opportunity for extreme specialization in cast iron, steel, or electrometallurgy.

Actual working practice in industrial plants is required after the first three years, in which case the student spends 7 weeks in a plant. After the fourth year, he spends 8 weeks in the plant, and after the fifth year, before receiving his Diploma, he works an additional 8 weeks in the plant. Finally, he spends six months in the plant or in the laboratory of the Polytechnic Institute, doing a thesis which is almost always associated in some way with industrial processes. This thesis work takes place from the 15th of September to the 1st of February.

In the course of his last two years, in addition to the courses which are delineated above, the student also has a variety of research problems in the laboratory. This amounts to about one day per week during the fourth and fifth years, or about 200 hr. He is encouraged to come in and utilize the laboratory facilities and to see the professors in the selection and working out of his problem.

Most institutes work on a five-year basis, but at the Leningrad Polytechnic Institute they have a five and one-half year program. In other engineering fields the types of course are similar but, of course, the specific courses can be quite different.

The laboratories used for instruction are very well equipped, with instruments built in Russia. The laboratory of ferrous metallurgy, for example, contains a number of high frequency generators and furnaces, a unit of a new and ingenious design for titanium melting by induction, an apparatus for vacuum arc melting, and one for vacuum fusion analysis of gases. In the metallography laboratory, there are five horizontal metallographs and nine vertical metallographs, fitted with cameras.

Moscow Institute of Ferrous Metallurgy

This is the teaching institute of ferrous metallurgy. It originated from the old mining academy and is on the same campus as are the following institutes: 1) Steel, 2) Mining, 3) Oil, 4) Peat, and 5) Mining Exploration. The enrollment has grown rapidly, and there are now 2500 students in the Stalin Institute of Steel alone; there are 50 professors and 120 teaching assistants, in all 240 teachers. This is one of the leading metallurgical institutes with respect to equipment and faculty. Within the Steel Institute are three faculties: 1) Metallurgical,

2) Technological, and 3) Physical Chemistry and Engineering.

Specializations within the metallurgy faculty of the Institute include the following: 1) blast furnace practice, including bessemer converters; 2) metallurgy of steel, including open-hearth furnace production and electric furnace metallurgy; 3) foundry; 4) production of heavy machinery; and 5) furnace technology.

Specialization in the technological faculty includes the following: 1) rolling, 2) forging, 3) metal fabrication, and 4) heat treatment. Specialization in the physical chemistry division shows two options: 1) physical chemistry of steelmaking, and 2) physics of metals, or physical metallurgy.

Courses in ferrous metallurgy and technological metallurgy are five-year programs, whereas those in the physical-chemical fields are five and one-half year programs.

In the first two years, all students must take a heavy complement of mathematics, physics, chemistry, strength of materials, and theoretical mechanics. Mathematics requires a two-year period, chemistry a two-year period, and physics a one and one-half year period. Some additional time is required in mathematics, chemistry, and physics if one elects the physical-chemical option. In the third year, one obtains general metallurgical courses such as: theories of metal processes, electrometallurgy processes, machine elements and components, and physical metallurgy. In the fourth year, intensive specialization starts even though actually one or two courses have already been offered in the third year.

One language is required which is either English or German for the undergraduate requirement, and a second one, including French as a choice, for postgraduate requirements. A reading knowledge is required without benefit of dictionary. They are now considering the possibility of asking that a speaking knowledge of English or German be required.

Practical experience in steel plants is required in addition to the school work. After the second year, excursions to steel plants are undertaken, and after the third year, 2 or 3 weeks are spent in a variety of different plants. After the fourth year, the student stays in one work shop for 8 weeks to obtain greater knowledge of his specialization. In the fifth year, two months of practice are required in a plant, and after that the student gets four months for the preparation of his Diploma thesis. It is also possible to do the Diploma research at the Institute rather than in industry, if a more scientific problem is selected. Prediploma work also calls for plant design or research at the Institute on special topics. After completion of this overall program, the student presents his thesis publicly, and a State Qualification Commission must certify his passing. In this State Qualification Commission, the presiding man is a representative of industry, some important person usually; and the Institute cannot veto the passing or failing grade that a student is granted. In this way industry rather than the Institute controls the Institute and its quality of students.

Starting last year, preference for entrance is being given to boys who have worked for two years at some industrial plant. These students must also have had 10 years of education, which is the current minimum requirement prior to entrance to any university or institute. The student age must be within 17 to 35 years to qualify, but most students are admitted at 17 to 20. While there is no objection to good women students, there is no doubt that men are preferred due to the hard nature of the work in the steel industry. It is estimated that the enrollment at the Institute probably comprises 20 to 25 pct women currently; this percentage will diminish due to the new preference system.

At Moscow railway station, Professor Morris Cohen of MIT, left, departs for Leningrad in company of Professor Finkelstein of the Moscow Steel Institute.

Examinations for entrance into the Institute are made up strictly by the Institute. It is estimated that there are from three to five times as many applications as there is space available.

After each semester, students have examinations and only passes are permitted. If a student fails one course, he is given another chance, but if he fails two, he flunks and is dropped by the Institute. On the other hand, if this same student, after failing, is properly qualified after two years of industrial practice, he may return and usually does. He generally turns out to be a much better student than if he had not had the experience.

About 90 pct of the students who enter graduate directly. Of those 10 pct who do not graduate on the first try, many go into industry and return at a later date, so that the number of graduates is nearer to 100 pct after all.

After graduation, it is the Institute's chore to get graduates the jobs they want. Since there are institutes in all areas of Russia, students do not have to go far from home in order to get the kind of jobs they want. In fact, it is usual not to send graduates far from home in order not to change their surroundings too much. There are claims that job choices are large, but that the best jobs are, of course, available to those boys with the best grades. This may mean that students at the bottom of the pile may not get the same fine choice of jobs. On the other hand, they do claim that no graduate is sent to a job unless he agrees that he is willing to take that job.

According to the requirements of the Institute and the Government laws, a student must stay at the first plant for a minimum of three years, after which he can leave that plant and select any other plant or any other job he wants through the usual job barter system.

Research: All professors must do research, and thus much research is done. Research is almost exclusively under contract for industry. There is some fundamental research, done mostly by the faculty, which is financed either by Government or by indus-

try. Emphasis as to the nature of research changes depending on whether the funds are supplied by the State Ministry for Education or by industry directly. There is considerably more industrial support than from the Ministry of Education.

Student organizations: There are two social organizations at this Institute, and this is generally true throughout the USSR: 1) The all-USSR trade union student group, sponsored by the Ministry of Higher Education, and 2) the Young Communist League. Students elect their own members and officers.

There is large participation in sports, both as part of the required curriculum during the first two years, and also as an extra-curricular activity on the part of the students through their own choice. The requirement is 2 hr per week. Sixty percent of the students do extra-curricula sports work, and 80 pct of all the students participate in the compulsory program.

Vacations include two weeks in the winter, from about the 25th of January to the 7th of February, and two months in the summer. The vacation period may be June and July or August and September, depending on the school curriculum and other factors.

Graduate study: Each professor usually has from one to three *aspirants* or Candidat students who are their postgraduate students. There are about 70 of these in the metallurgy division now who will study for a period of three years, and the work is of a scientific nature. The stipend of a postgraduate student is 1000 rubles per month. If he is from out of town, accommodations are provided, and he must pay a small fee of about 15 rubles per month. To become a Candidat, the student must pass an entrance examination. Prior to admission he must show at least one publication or a written treatise on some special topic in order to qualify for entrance. The professor with whom he will study must be definitely convinced that the aspirant will be able to do the research and meet the requirements. The postgraduate must be prepared to defend publicly a dissertation, after which he gets his Candidat degree. In the first year, there are some lectures, but for the most part formal lectures are not given at the graduate level.

A Scientific Council presides at the public oral examination on the thesis, and the thesis is publicized in the newspapers prior to the presentation. The Scientific Council casts a secret ballot to determine whether the man has passed or not. The Scientific Council is the final authority. The Special Commission of the Academy of Science gives the Candidat degree and can interfere with the decision of the Scientific Council, but this practically never happens.

The Candidat can get his degree directly from industry without attendance at one of the universities. In case an aspirant from industry submits a thesis, there is a possibility that he can fail, because he has not had close supervision of someone at the Institute; on the other hand, the Institute Candidats who progress as far as the examination will very rarely fail. Postgraduate students must have two years of industrial experience but are not required to return to the same institute where they acquired a Diploma. The postgraduate can also do his entire research at a place like the Baikov Institute instead of at the university.

The Scientific Council is composed of heads of the scientific chairs and professors of the departments, but it may also be staffed with one or two industrial representatives. However, each person has only one vote, and the industrial control, which is so prevalent at the Diploma level, is not at the Candidat level. As a basis for the Candidat examination, two opponents are picked, one of whom is a professor at the Institute and the other one from industry, to criticize the thesis and point out weak points, etc., and generally to make recommendations regarding the validity of the conclusions and the quality of the work.

Supply of metallurgists

We asked questions concerning the supply of metallurgists and other scientifically trained people. The general opinion was expressed that the country had plenty of metallurgists. There are a substantial number of institutes training metallurgists and there is no shortage. They are turning out something like 2500 ferrous metallurgists per year; the number in non-ferrous would be a little smaller, yielding a total of about 4500 Diploma graduates per year. It was estimated that there are in the USSR about 115 Candidat degrees per year in ferrous metallurgy. The opinion was expressed at the Stalin Institute of Ferrous Metallurgy in Moscow that all fields of science and engineering are well provided with personnel. A statistic was quoted to the effect that in all fields of learning there are 80,000 Diploma graduates per year.

Summary and conclusions

The outstanding difference between the Russian system of training metallurgists and our program in metallurgical education lies in the high degree of specialization in the last two years of the Russian program, plus the requirement for practical training in industry.

In the first three years, the two systems might be considered fairly comparable, but in the fourth and fifth years the Russian students study subjects and engage in industrial activities which we will not impose upon our students, even in the so-called practice schools or cooperative programs. Much of the training in these years is on subjects which we expect our students to learn after they have graduated and taken jobs in industry. These last two years are, in fact, training for industry rather than education, and this is a road which most of our better schools have avoided.

There can be little doubt that the Russian students are well trained for the specific industry they intend to enter. Undoubtedly, all or nearly all of them enter the industry for which they are prepared. This is quite a different situation from that prevailing in the U.S. where a young man on graduation might select any one of dozens of industries. Undoubtedly, the graduate engineer entering industry goes in with a fairly clear concept of the work he is to do, and probably his contributions during his first year are greater than the industrial contributions of graduates in the U.S. It is doubted, however, that the narrow training he has received can be considered anything approaching the ideal training for the long pull. It is said that the Russian Diploma is roughly equivalent to our Master's degree. This would be true if our Master's degree involved narrow specialization, which it generally does not. Perhaps one could say that the Master's degree involves substantially more education, but that the Diploma involves more training.

The lessons which we have learned from visiting Russian metallurgical institutes may be summarized briefly as follows: The general program is tailored to the needs of Russian industry. Each student is well trained for a specific kind of job in a specific industry. The product seems to be satisfactory to industry, and it appears that a Diploma in metallurgical engineering is a sine qua non for industrial advancement. The degree of specialization and the extent of training go far beyond the usual American practice. To a considerable degree, educational breadth is sacrificed to specialized training. This is a sacrifice which cannot be recommended to American schools.

In numbers, the Russians are far ahead of us in the training of metallurgists. More emphasis should be given to metallurgy in American schools, and renewed efforts must be made to increase the enrollment of superior students. Laboratory equipment for instruction in metallurgy in the Russian schools is superior to that in our own. This is true in respect to the quantity of good equipment available and the diversity and advanced nature of the laboratory experiments for which equipment is provided.

Non-Ferrous Metallurgical Training

David Swan, Director of Research, the Linde Co., Div. of Union Carbide Corp., had some interesting comments on the Kalinin Institute for Non-Ferrous Metals in Moscow. . . .

Non-ferrous teaching institutes are located in Moscow, Leningrad, Alma-Ata, Irkutsk, and Sverdlovsk, but the Kalinin Institute in Moscow is the largest in the USSR.

The primary purpose of the Kalinin Institute, which was founded in 1930, is to teach engineers for jobs in the non-ferrous metallurgical industry. There are five departments comprising: geology, mining, metallurgical, technological, and economic engineering. The department of metallurgy has two specialties: enrichment of ores and metallurgy of non-ferrous metals. The technological department has three specialties: metallography and heat treatment, treatment of metals under pressure, and smelting and reduction.

Approximately 2500 students attend the Institute for a five-year course. In addition, there are about 200 graduate students. The teaching staff consists of 300 of whom 40 are professors with doctor's degrees and more than 100 teaching assistants with Candidat degrees.

Approximately five subjects are given during each academic year, which is divided into two terms plus a practical work period. For the first two years, students attend school full time, but after the second year they spend 7 to 8 weeks per year on practical production problems in plants and factories. About one third of the total study time is in the field of general sciences, such as mathematics, physics, and chemistry, while the remainder is in physical sciences on subjects pertinent to the specialty chosen. These studies begin in the second or third year, depending upon the specialty. Humanities comprise courses in dialetical materialism, historical materialism, political economy, and a language, either English or German. No literature or history are given.

The choice of specialty is supposedly voluntary. The specialties given in the department of metallurgy include: heavy metals, light metals, rare metals, and noble metals. In the technological department specialties consist of metallography, heat treatment, and smelting. The metallography specialty is further broken down into subdivisions comprising powder metallurgy, corrosion, and electrochemistry. The student chooses his faculty (department) immediately upon entering the Institute.

Examinations

Formal examinations are given twice a year, in January and June. If the course runs for a full academic year, only one examination is given, in June. All examinations are oral. They are marked on a scale of five for excellent, going down to two for failure. For the examination the student is handed a ticket on which is printed three questions which he must answer. Informal examinations are given during the course of the semester, and questions of the same type are included in these examinations. The oral examinations are given individually and last for approximately 30 min. Written tests are also given during the course of the year.

The stipend

Whether or not a stipend is granted is determined by need and the record of the student. After the first year it is based entirely upon the school record. At the present time 85 pct of the students receive stipends which may be rescinded for either poor discipline or poor marks. The size of the stipend is 300 rubles per month for the first year and increases progressively to 500 rubles for the fifth year students. Rooms are furnished by the Institute at approximately 15 rubles per month. Board must be paid by the student, who makes his own arrangements.

Job selection

The school record is very important in the selection of a job upon graduation. A list of plants requiring different types of specialties is posted at the school, and a committee composed of the director of the Institute, representatives of the Institute, and representatives of industry assign students to the various job opportunities. In many cases, after the students and jobs are matched by this committee, the plant manager may interview the student and may rescind an offer. The student may also turn down a specific job offer. In some cases the number of graduates are greater than the jobs available, and then the student must find his own job.

Sverdlovsk Polytechnic Institute has 15,000 students of which 1000 are in metallurgy. The curriculum is similar to that of the Leningrad Institute. The metallurgy department includes laboratories for research in iron, steelmaking, casting, rolling, ore treatment, non-ferrous metals, phase diagrams, kinetics, and analytical chemistry.

Quantity and Quality in Russian Metallurgical Education

For further comments on Russian metallurgical education we turned to Walter R. Hibbard, Jr., Manager of Alloy Studies at the General Electric Research Laboratory.

In the institutes and colleges in the USSR most students study free of charge, and the State pays the entire cost plus a stipend. For students at the Moscow Steel Institute, the stipend is 400 rubles per month in the first year and some additional rubles per month for each ensuing year. It was said that this stipend is more than the average income per person in Russia, since 800 to 900 rubles per month is the average income per family, and four persons is the average family size; hence, the average income is from 200 to 225 rubles per person. Studying certainly seems to be a paying thing in the USSR, and apparently young men and women are aware of this, since there are several times as many students applying for entrance to in-technical colleges and institutes as are accepted.

The size of the educational effort in metallurgy is quite impressive. By simply totaling the number of metallurgical graduates from the five institutes visited, it comes to about 2000 to 3000 per year. This is approximately four to five times the number of metallurgists which are graduated in the US. These graduates have had a five or five and one half year course, which appears to be approximately equal to the average metallurgical course in the US. One first wonders how they can absorb this large number of metallurgists into a metals industry which is smaller than that of the US. Actually, they may use these metallurgists for many jobs which would not require metallurgists in the US, or else they may put a large number of people on a given job, possibly without regard for economics, but solely with regard to the effects on production.

The educational courses appear to be intensive, requiring hard work and a rather strong financial and career incentive. The professors and teaching staff with whom I came in contact appeared to be quite familiar with existing knowledge in their subject and in particular with the published literature of all countries.

The educational facilities, in so far as equipment was concerned, were approximately equivalent to the average facilities in an American university, but the buildings were worn and in need of repair. The classes were small, usually involving groups from 6 to 25, particularly in the last two years. The educational institutions all engaged in some research, but it appears that much of this was descriptive.

Impressions of Russian Technical Education

An interview with Professor Morris Cohen of the Massachusetts Institute of Technology produced some interesting comments on technical education in the USSR.

"The Russians are training good engineers" was Professor Cohen's reply to questions about the adequacy of Soviet education. We put it this way, "There is an impression that the Soviets have been training technicians rather than educating engineers. We gather that the Russian technical schools, with their close links to industry, attempt to train for a specific type of job, almost in a specific plant. Doesn't this type of approach result in a very narrow engineer who can not adapt himself to new situations and different ideas and problems?"

"No", said Professor Cohen, and he went on to point out that Soviet education is an overall integrated system; therefore, one must look at the primary and secondary education as a part of the whole. It is in the secondary schools that the potential engineer starts the fundamentals of mathematics, physics, and chemistry, while he is given two to three years of basic and applied science in technical institutes before beginning to specialize in a relatively narrow area during his last two years of formal education. It is this background, building up step by step through the fundamentals for 10 years in primary and secondary schools plus two of the college years that produces a well rounded engineer. "The Soviets have good general engineers in spite of their specialization", concluded the professor.

Are the humanities neglected? This was our next question posed to professor Cohen. "They are not emphasized to the extent that they are in America, but they are not completely neglected either. Here again you must look at the overall educational program, including primary and secondary schools. It is in the grade schools that humanities, such as literature, history, geography, art, and music are taught. Soviet educators apparently feel, that upon reaching the university level the student has largely completed this phase of his education. Economics, foreign languages, physical education, philosophy and Marxism-Leninism are just about the only non-technical subjects offered in technical colleges. There appears to be no such thing as a liberal arts education in Soviet universities, although a student may specialize in history, law economics, and similar fields."

Can most Soviet metallurgists read English? "Most of those we met could certainly read English, although few were able to speak to us without interpreters," replied Professor Cohen, who explained that six years of foreign language are required in primary and secondary schools, starting in the fourth or fifth grades. Five additional years are required in the university. The greatest emphasis by far is on English, although German and French are also important.

How does secondary education compare with the US? The answer did not appear to be difficult for Dr. Cohen, who pointed out that Soviet secondary school students are not provided with a wide array of electives which they may take at almost any time and in almost any sequence. "Each subject is introduced in what is felt to be the proper order. Mathematics through trigonometry, chemistry, physics, biology, and astronomy are required in all secondary schools as a part of the general education. Entrance examinations are a necessary prerequisite for admission to any higher educational institution, and all examinations are of the same level, requiring a fundamental knowledge of mathematics and science, as well as Russian, and a foreign language."

Is there an overly formal atmosphere in colleges? "Well, the students certainly do have the same respect for professors that is characteristic of German universities. There is little or no social intercourse between students and faculty. It would appear that students generally accept the teachings of their professors without much question, but this is not so much a matter of regimented obedience as of respect."

What about the economic position of professors? "University professors are certainly at the top of the economic, as well as the social, ladder, and their earnings are from ten to fifty times those of laborers. There appears to be no shortage of teachers. By means of the stipends paid to college students it is quite easy to control the flow of students into the various professions by regulating the value of stipends. Furthermore, the young person in the Soviet Union is attracted to higher education, since the stipends are commensurate with wages paid to common laborers."

How do you feel about your reception in the USSR? Dr. Cohen felt that he was given excellent opportunities to visit research institutes and talk with specialists in various fields. Certain things were not shown, but on the other hand, the Russians were not shown everything on their visits to the US. Dr. Cohen feels that there is a good chance for a gradual opening up on both sides.

Summarizing, the main points which Professor Cohen brought out on Russian technical education:

1) Russian engineers are not overspecialized for their purposes when one considers the amount of basic and applied science given them in secondary schools and in their first two years of higher education;

2) The teaching of science and engineering is firmly based on the educational process of the secondary school system. Russian education must be considered as a whole, since it is part of an integrated plan;

3) Every student in the secondary schools must take stiff courses in science and mathematics; and

4) The humanities are virtually neglected in higher education for scientists and engineers. Apparently, reliance is placed on the secondary schools for the non-technical subjects.

by J. H. Hollomon and W. R. Hibbard, Jr.

METALLURGICAL RESEARCH IN THE USSR

The authors have observed Soviet research in physical metallurgy at several universities, teaching institutes, and research institutes in Moscow, Leningrad, and Sverdlovsk and found:

a) Metallurgical research impressive although little known in the US, and

b) Soviet scientists able to read English and quite familiar with American research work.

They conclude that,

We must become familiar with Russian technical literature and place emphasis on the ability to read Russian.

IT is difficult to assess the present state of metallurgical research in the Soviet Union. This arises from several causes: First, we have not been receiving, until recently, the Russian metallurgical literature in western countries. Second, the rate of growth of both the size and the number of Soviet publications devoted to metallurgical and metallurgical research is very great. Third, very few metallurgists have visited the USSR, and few Soviet counterparts have visited the US. But the size and intensity of the Russian effort in physical metallurgical research is very impressive.

Research concentrated in areas

Soviet metallurgical research has its greatest emphasis in fields related to the production of ferrous and basic non-ferrous metals, and it appears to be concentrated strongly in certain areas. Some fields, such as the chemistry of steelmaking, receive tremendous support, while certain fields, considered to be of equal importance outside the USSR, appear to be neglected. For example, the martensite reaction in all its ramifications has received great attention compared to the equally important transformations of ordered-disordered reactions, precipitation, grain growth, etc. This concentration is certainly related to the eminence and excellence of the work of one of the greatest Russian metallurgists, Kurdjumov, but it also reflects the power of one man to influence, to a great extent, the country's metallurgical research.

The spirit of Soviet research is not completely unlike that in the western world, but with notable exceptions. In the West, fundamental research tends to be mechanistic; models are conceived and their behavior predicted and compared with experience. In the Soviet Union more empirical correlative approaches are often used. A somewhat greater difference is the appreciation in Soviet industrial, governmental, and academic institutions of the needs of the nation, with corresponding tendencies in their research to concentrate in certain areas to meet these national needs.

Organization of research

Physical metallurgical research is carried out in several types of institutions. Government-sponsored research is done in institutes operated by the Academy of Science, such as the A. A. Baikov Institute for Ferrous Metallurgy in Moscow. In addition to the main branch of the Academy of Science in Moscow, there are thirteen auxiliary branches, such as the Institute for Metal Physics of the Ural Branch of the Academy of Science in Sverdlovsk. These institutes support large physical metallurgical efforts, the Baikov Institute having 20 laboratories and 1300 people, and the Institute of Metal Physics having 200 people and 11 laboratories. Seventy percent of the work in the Baikov Institute originates in the Institute and 30 pct in the outside ministries. Programs are based on up to five years' duration and cover such diverse fields as steelmaking, high temperature alloys, semi-conductors, fracture, and dislocation theory. At the Institute of Metal Physics in Sverdlovsk, a major portion of the Russian work in ferromagnetic materials is carried out, in addition to well-known work on oxidation and diffusion. The facilities in these institutes are quite modern and impressive; they include x-ray, electron microscopy, electron diffraction, emission microscopy, Castaing-

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type x-ray microfocus analyzer, and nuclear magnetic resonance devices.

Research is also carried out in institutes sponsored by industry under the Gosplan. An example of this is the Central Scientific Research Institute for Ferrous Metallurgy in Moscow and the Central Scientific Institute for Technology and Machine Building. The former is a large institute consisting of 1500 people and 20,000 sq m of floor space, under the direction of Academician Bardin, and operated for the steel industry. There are similar institutes in Sverdlovsk and Kharkov. They do research on steel, ranging from melting and refining to metal physics. These institutes are also large and well equipped.

A third type of institution where research is being done is the academic institution. At the Moscow State University, for example, the Department of Physics is a large, impressive institution with extensive buildings. The equipment is adequate but not as elaborate as the government or industrial institutes.

A second type of academic institution doing research is the polytechnic institute. The Leningrad Polytechnic Institute is also an educational facility with large and impressive neoclassic buildings and having about 11,000 students. In this institute, metallurgy is only one of several engineering disciplines. Facilities which were primarily for teaching were comparable to what one might see in a similar institute in the US.

The third type of academic institution for metallurgical research is a teaching institute, such as the Moscow Steel Institute in honor of Stalin or the Moscow Institute for Non-Ferrous Metals and Gold in honor of Kalinen. Teaching institutes are operated by the Ministry of Higher Education and are unlike anything which one might see in the US. The Moscow Steel Institute for example, has approximately 2500 students, all of whom are being trained to be engineers for the steel industry. The research in these institutes is somewhat less extensive and possibly not quite as well supported by the Soviets as research for industry or the Government research institutes.

People—many in research

As is the case with organization facilities, one is immediately impressed with the large numbers of people working in the field of metallurgical research. For example, at the Baikov Institute, there are 1300 people working on ferrous metallurgy, at the Central Scientific Research Institute for Ferrous Metallurgy, another 1500, and at the Central Scientific Institute for Technology and Machine Building, another 2500. At Moscow State University, there are about 2000 faculty members and 1500 graduate students, many of whom are doing research. Their research budget is 15,000,000 rubles a year (1½ to 3¾ million dollars) which gives some idea of the order of magnitude of the effort. At the Leningrad Polytechnic Institute there is a faculty of 1000 including 100 professors, most of whom were doing research in certain fields of engineering. At the Ural Branch of the Academy of Science, there are 1400 people doing research including some 200 in metal physics. At the Moscow Steel Institute, there are 240 faculty members and about 120 graduate students, most of whom are concerned with research work. Similarly at the Kalinen Institute for Non-Ferrous Metals and Gold, there are 300 faculty members and 200 graduate students, most of whom are doing research work.

Their programs appear to be designed to use more people than in the US. Once they decide to investigate a subject, they cover it very extensively and intensively, including many types of experiments and measurements on a systematic empirical basis. Such a program requires considerably more manpower, than one designed on a mechanistic basis.

Scientific information

Possibly the most impressive Russian effort is in their utilization of scientific information. This effort manifests itself in several ways.

First of all, everyone seemed to have a remarkable familiarity with the scientific literature of Russia as well as of Western Europe and the US. This familiarity results from two things; first of all, the student who is graduated in metallurgy from such institutions as the Moscow Steel Institute or the Kalinen Institute for Non-Ferrous Metals and Gold, for example, is required to learn to translate English at a remarkably facile rate of 3,000 units per hour, which is approximately 500 words. Therefore, the scientists doing research in metallurgy, for the most part, can read English reasonably well and follow American literature in its original language. In addition, many of them can translate either German or French.

The second important point is that the Russian and the foreign literature is available to all these individuals through rather extensive libraries. For example, the library at the Moscow State University has 5 million volumes; at the Leningrad Polytechnic Institute, they have a library of 1.5 million volumes and they take 100 American and 100 Western European periodicals in the scientific fields; thus, the Russian scientist not only can read English but he can also go to the library and get the American and English journals approximately six months after they are issued.

Further, there is a very large Government organization for disseminating scientific information; namely, the All-Union Institute for Scientific Information. Here, most of the important American works are translated into Russian and disseminated to scientific workers. These translations are generally done by scientists, for example, Professor Livshitz at the Moscow Steel Institute assisted with the translation of Bozorth's book on ferromagnetism.

There are a large number of scientific texts written in Russian. There is a wide financial and prestige encouragement for professors and scientists to write books on their specialties so that on almost any subject in the field of physical metallurgy, one can find a text which has been written by someone of reasonable authority in this field. These books are also inexpensive, relative to books in the US.

Scope of the work

Areas in which the Soviets publish extensively may be summarized as follows:

Mechanical Behavior of Properties and Materials. Here, there is a tremendous effort on the development of high temperature alloys, almost exclusively using a thermodynamical approach involving binding in these alloys as measured by the Debye temperature. There is work on high-temperature solid-solution alloys based on static and dynamic lattice distortion, supplemented by extensive work on hardness, hot-stage metallography, and some work correlating creep behavior to diffusion. However, in contrast to this, there is a relatively small effort on the structure sensitive aspects of mechanical be-

havior, creep, fatigue, fracture as related to slip, and dislocation theory.

Electrical Behavior of Properties and Materials. Here, there is interesting work on superconductivity as related to crystal structure and interatomic spacing, work on semiconductors, primarily involving the effect of pressure, and some work on Hall effect and electrical and thermal conductivity.

Magnetic Behavior, Properties and Materials. Here again there is the work on the magnetic effect of phenomena such as ordering and clustering, interaction between dislocations and domains, shape anisotropy, and domain patterns in general. There is some work on permenant magnet alloys of the Alnico type and of the Vicalloy type and rather less work than expected on the texture processing in silicon-iron.

Origin and control of structure. Here there is extensive work on the martensite structure and martensite reaction, rather limited work on recrystallization (much less than there is in this country for example), an extensive program on binding and solid solutions as interpreted from Debye temperature measurements, extensive diffusion work, and some internal friction measurements. There is some work on the ordering reaction, and on precipitation involving Guinier-Preston zones, as well as extensive work on x-ray and electron techniques for documenting structure.

Processes (Kinetics, energetics, etc.). There is a large amount of work on diffusion, particularly the effects of solute additions on diffusion, some work on oxidation, on gas metal reactions, and rather good work on solidification and melting techniques. In the area of constitution and thermodynamics, there is extensive phase-diagram work on transition elements and some good work on slag-metal and thermodynamic studies

Metallurgical literature

A survey of references to Soviet metallurgical literature in the ASM's Review of Metal Literature Abstracts for 1956 has shown that a significant portion of the metallurgical research done in the world is reported in Soviet literature—at least 10 pct. In certain areas of metallurgy, Russian literature is nearly 20 pct of the total; these areas include: transformations and resulting structures, mechanical properties and deformation, and ferrous reduction and refining. Other areas of concentrated Russian effort amounting to some 10 to 15 pct of the total includes the fields of metallography, constitution, and primary structure; physical properties and test methods; and primary mechanical working. The size of the Soviet effort is probably understated, since recent visits have uncovered publication media not available at the time of this survey.

Summary

In summary, the size, intensity, and concentration of the Soviet metallurgical effort in certain areas of science and development is impressive.

We think it is important that American metallurgists become familiar with the Russian scientific and technological effort in the field of metallurgy, both through their literature and its translation and by personal contacts, where possible. In this way we this information into the store of knowledge on which our scientific programs are based.

We believe that the Soviet Metallurgical effort will continue to be large, concentrated, extensively supported, and directed towards specific national problems or the phenomena upon which they depend.

Coordination In Soviet Education and Research

by Leslie Seigle

As a member of the New York University—Moscow Steel Institute exchange of metallurgists, the author had the opportunity to visit more than a dozen of the major research and teaching institutes in the Soviet Union. His notes on the coordination of technical effort under communism are presented in this article.

THE socialization of technology permits the integration of scientific effort on a vast scale, and the attention of a visitor from a free to a controlled society is attracted by examples of coordination in schools, research institutes, and industry. Of course, the most striking of these is the regulation of the supply of scientists and engineers by the demands of industry. Each plant sends a list of its requirements for trained personnel to the governmental agency under which it operates. These lists work their way upwards to the State Planning Commissions where the educational requirements are analyzed, enrollment quotas and other plans are established for the technical institutes, and after an appropriate interval, the required manpower appears on the scene.

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Curricula tailored to industry's needs

It is natural to expect, with detailed knowledge available via the foregoing mechanism, and others, that school curricula are closely tailored to the needs of industry, and this is apparently true with regard to the complex pattern of specialization

which exists in the Soviet technical institutes. At the Moscow Institute for Non-ferrous Metallurgy, for example, we were told by Professor Lysovsky, Dean of the Metallurgical Faculty, that because of the need for modernization of the non-ferrous industry of the Soviet Union, a new specialization had recently been introduced into the curriculum, entitled "Automation for the Non-ferrous Industry". Two of the courses given under this specialty were "Theory of Automatic Regulation" and "Use of Radioactive Tracers in Automation". In addition, two specialists from the Institute of Automation of the Russian Academy of Sciences were imported to teach these courses. One is impressed not only by the establishment of such specialized curricula in response to demand, but also by the existence of equally specialized research institutes, working closely with schools and industry.

In addition to the activities of teaching and research institutes being coordinated with the demands of industry through governmental agencies, extensive direct contact exists between industry and the institutes. In the Non-ferrous Institute, we were told by Professor Spasky, Acting Director of Research Work, that research is conducted by each member of the staff in two categories: 1) fundamental research in various specialties, and 2) research on the problems of industry, under direct contract to manufacturing plants. The volume of work in the second category is almost 50 pct of the total research load.

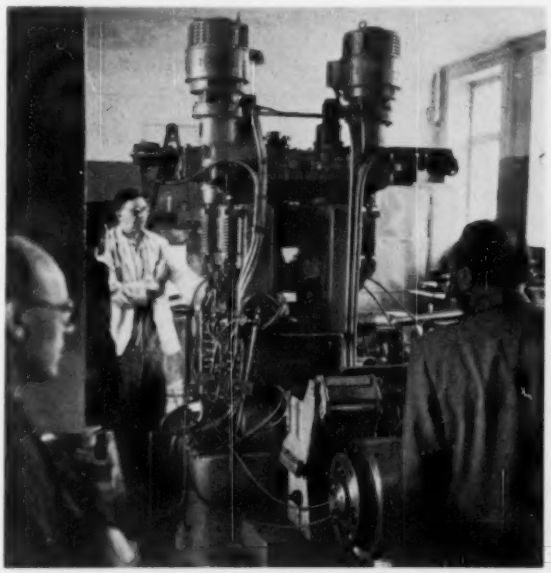
The same division of effort exists in the Leningrad Mining Institute and Central Research Institute for Machine Construction in Moscow. In th Leningrad Polytechnic Institute, it was stated by the Director, V. S. Smirnov, that the entire research program is based upon the needs of industry, particularly industry in the vicinity of Leningrad. There can be little doubt that a widespread and vital exchange of information between industry and the institutes occurs via extensive sponsorship of research programs.

Exchanges and consulting agreements

There also exists an apparently broad program of exchanges and consulting agreements between the research and teaching institute staffs and industry. It is common for teams of experts from the research institutes to visit industrial plants for extended periods of time, to aid in the installation of new equipment, or to transfer experimental processes from laboratory to plant scale. This procedure is very logical, since the higher research institutes have the authority to force the adoption of new techniques in industry over the protests of conservative factory managers. Allowing the research experts the privilege of proving their ideas in large scale operation probably prevents unhealthy overenthusiasm for innovation. There seems also to be many staff exchanges between institutes and between institutes and industry for lecturing and other teaching or research purposes. Director Unksov of the Central Research Institute for Machine Construction in Moscow informed us that the staff of his Institute lecture at about 800 industrial plants. On the other hand, industrial research scientists and engineers may serve on committees which compile source syllabuses, examine textbooks, pass on graduate dissertations, review academic appointments, and pass judgment on the quality of research and teaching in the institutes.

Coordination by multiple directorships

The coordination of research effort among institutes is aided by the frequency of multiple directorships, i. e., the practice of an individual holding supervisory posts in a number of institutes. For example, Bardin, the Director of the Metallurgical Institute of the Russian Academy of Sciences, is also Director of the Central Research Institute for Ferrous Metallurgy. Kurdjumov, Director of the Metal Physics Institute of the Central Research Institute for Ferrous Metallurgy, is also Head of the Phase Transformation Dept. of the Metal Physics Institute of the Ukrainian Academy of Sciences.



At the Ural Branch of the Academy of Science of the USSR in Sverdlovsk an experimental mill. Picture by John Chipman of MIT.

It seemed to me that very little *class distinction* was recognized among the various types of research and research workers in the Soviet Union. Fundamental researchers could frequently be found dealing with common industrial materials and problems. For example, Kurdjumov's work on separation of the static and dynamic components of lattice distortion due to solute atoms is being carried out with conventional low-alloy steels. The discovery of an internal friction effect due to interstitial carbon in a face-centered-cubic metal (a Russian first) was made in experiments with 25 Cr-20 Ni heat-resistant austenitic steel. Borovsky, studying the electronic structure of transition metals in the Academy of Sciences Metallurgical Institute, is also working on rapid methods for determining oxygen, hydrogen, and nitrogen in steel. This amalgamation of scientific and technical interests may be a matter of government policy, since there is evidence that *ivory-towerism* is officially frowned upon.

To obtain a complete picture of the organization of Soviet technical activity would obviously require a lengthy study, and the foregoing represents merely a few observations and impressions from an only too short visit.

by Claus G. Goetzel

POWDER METALLURGY IN THE USSR

Since the 1957 New York University—Moscow Steel Institute exchange arrangements emphasized physical metallurgy and metallurgical education, plant visits and insight into production methods were restricted to a few cases. These did not include powder metallurgy; therefore, the first-hand information gathered relates entirely to research and development.

THERE is considerable evidence that a great number of theoretical studies are being carried out by several Soviet scientists of high reputation, such as Prof. A. G. Meerson of the Kalinin Institute for Nonferrous Metals and Gold, Science Candidate M. Yu Balshin of the Baikov Institute of the USSR Academy of Sciences, and Prof. I. N. Frantsevitch of the Metal-Ceramic Institute of the Ukraine Academy of Science. Subjects under intense study are recrystallization, volume and surface diffusion, surface energy, capillary action, infiltration, evaporation and condensation, and bonding. The solid-state mechanism of sintering is given particular attention, as is the interaction between metal powder compacts and gases. It appears from recently published voluminous accounts that each of the scientists has his own theoretical concepts and no unified theory of sintering covering all important aspects of the process has yet been advanced.

High priority is given to phase diagram studies in all powder metallurgy alloy development work, as in the case of high temperature materials based on intermetallic compounds or refractory metal alloys. These studies are carried out in the laboratories of technical institutions, universities, and those of the Academy of Sciences.

Fundamental work on the powders themselves, especially on fine sizes reaching into the colloidal range, was not in evidence. But studies of processes of compaction and consolidation were in progress both at Baikov and at Kalinin. They encompass such interesting approaches as powder roll bonding and high temperature pressure sintering.

Powder metallurgy of titanium

One of the most interesting developments to this reviewer was the result of a five-year, 30-man effort on titanium powder metallurgy at the Central Scientific Research Institute for Ferrous Metallurgy, under the able guidance of Science Candidate N. N. Timoshenko. Products shown included large sheets, thin foil, pierced tubing, thin wire, and compressor or turbine blades. The sheets were over 3 ft wide, 6 ft long, and 0.120 in. thick. The foil had a thickness of less than 0.005 in. and was rolled on a Sendzimir-type mill. The tubing was about 1½ in. OD and 1 in. ID and 12 ft long. The wire was of filament size, less than 0.005 in. in diam. The blades were relatively large and displayed flash from the incompletely closed forging dies.

Some of these products were made from the metal powder, but most from alloy powder. According to Timoshenko, a co-reduction of the mixed oxides was the preferred production method. Processing of the powder included hydrostatic pressing, high temperature vacuum sintering, and hot die forging. Hot and cold rolling followed in the case of the sheet and foil, and diamond die drawing in the case of the fine wire. Hydrostatic ingots were about 15 in. long, 6 in. in diam. It appeared that hot pressing of titanium powder was not used by this laboratory at this time.

The mechanical properties of forged titanium ingots were given as 92,000 psi tensile strength, 30 pct elongation, 25 pct reduction of area, 180 Brinell hardness. A typical alloy product in the forged condition had a tensile strength of 142,000 psi, an elongation of 15 to 20 pct, a reduction of area of 10 to 15 pct, and a hardness of 210 Brinell. Hot rolling of the same alloy to sheet increased the tensile strength to 156,000 psi, the elongation to 30 to 40 pct, and the reduction of area to 20 to 30 pct. Hardness then dropped to 195 Brinell.

Powder metallurgy of beryllium

Prof. Meerson spent considerable time discussing this subject. Apparently a major effort is going on at Kalinin Institute under his direction. Powder metallurgy is held to be the ideal technique to produce sheet of satisfactory engineering ductility. Although grain orientation and the concommittant embrittlement in the transverse and especially perpendicular directions to that of rolling are unavoidable, these effects may be considerably reduced, due to a very fine initial grain size and careful manipulation. This was evidenced by some rather flexible strip shown.

Meerson described their process essentially as consisting of magnesium reduction of the fluoride, machining and ball milling under argon of the granules to a 325 mesh powder, hydrostatic pressing, vacuum sintering, and hot rolling. Hot pressing apparently is not in use at present.

Intermetallics and cermets

Carbide base cermets are the subject of intensive work, both at Kalinin Institute under Meerson and at Baikov Institute under Balshin and his coworker,

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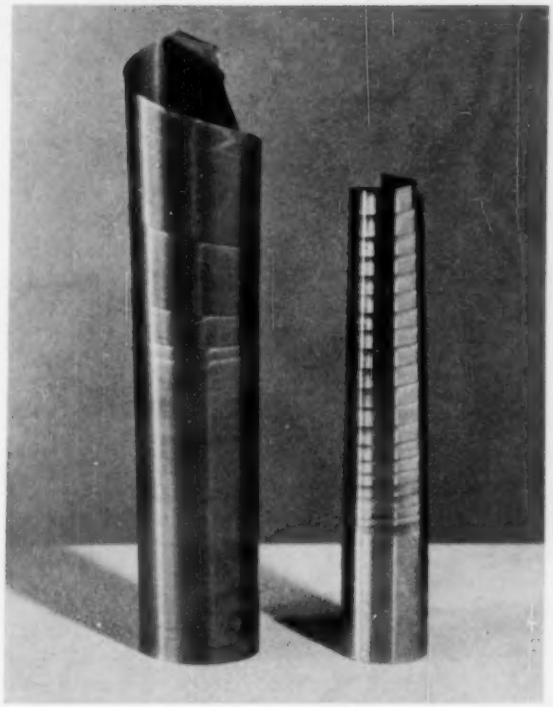
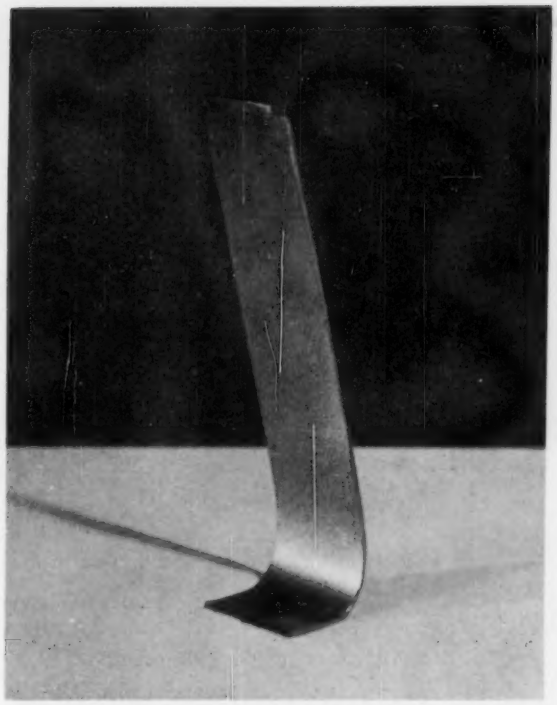


Titanium alloy foil 0.005 in. thick made by powder metallurgy techniques in the USSR.



Roll-bonded and sintered stainless steel powder strip produced in the USSR.

Science Candidate C. A. Zuckerman. Titanium carbide cermets with high columbium bearing nickel and cobalt binder alloys were one interesting offshoot of the conventional cermet grades in the Western countries. According to Zuckerman, the columbium-rich binder greatly enhances the high temperature oxidation resistance, although the intrinsic lack of engineering ductility does not seem to be overcome. In this respect Balshin gave the impression that (a) the overt lack of mechanical and thermal shock resistance of these cermets is not necessarily an obstacle to their application in engines and structures, and (b) researchers and development engineers so far have failed to learn to control the raw material and processing variables sufficiently, so that a cermet with the desired properties can be produced. The historical development of the cemented carbide cutting tool may well serve as a guide.

Very surprising was the fact that Balshin and Zuckerman were working with a large group of technical personnel on a fundamental investigation of intermetallic compounds as a preliminary to a new class of cermets. Some of the systems now under study in a parallel effort include silicon-carbon-boron, titanium-carbon-boron, titanium-chromium-boron and columbium-tungsten-silicon. The first objective of this work is to establish phase diagrams and physical properties of a considerable number of ternary and quarternary compositions based on carbon, boron, silicon, and the refractory metals. A later objective is to investigate the intermetallic compounds, their interaction with other compounds and with metals. Finally an attempt will be made at the development of new cermet compositions for which the findings in the first two phases are deemed invaluable. Balshin indicated that the program had been conceived by them on the basis of published information in this general area. A carefully worked out plan encompasses several years of intensive research with the present group of investigators.

It may be mentioned here that powerful and up-to-date equipment is available for this work. A pressure sintering furnace, for example, permits sintering of tensile specimens of 6 in. length in a vacuum of 5×10^{-5} mm Hg at 2200°C. During the operation a pneumatic pressure of 2 tons is applied to the graphite punch.

Other activities

Powder metallurgy work was demonstrated in several other areas, which can only be briefly mentioned in this report. Apparently considerable effort is expended in some of the refractory metals and their alloys. An alloy of tungsten with 20 pct rhenium produced at Baikov is but one example. The alloy was demonstrated to have very good room temperature ductility. It appears that some work is also going on with dispersion strengthening of refractory metal alloys as well as alloys based on the transition elements. Here, however, little concrete evidence of interesting test results could be discovered.

Considerable advance was shown in the direct rolling of stainless steel powder at Baikov. An up-to-date powder rolling facility was demonstrated to produce porous as well as dense strip which displayed excellent ductility after sintering.

In summary, research and development in powder metallurgy in the USSR seems both advanced and intense, but no really spectacular results were noticed, with the possible exception of the titanium, beryllium, and ductile tungsten products mentioned. However, further progress in these areas by the Soviets can be expected and bears careful watching.

TULA SVERDLOVSK CHELYABINSK MAGNITOGORSK...KEY RUSSIAN STEEL PLANTS

In the course of a three-week visit to the USSR in June and July of 1957, professors Grant and Chipman of MIT were fortunate to have been invited to visit four Soviet steel plants, traveling as guests of the Russian Academy of Sciences.

by Nicholas J. Grant and John Chipman

OUR first visit was to the Tula plant, which is located about 120 miles south of Moscow. This plant was of particular interest to us because, while it is a full-scale operating plant with an annual production of about 500,000 tons of pig iron, large portions of it are operated as experimental units.

This steel mill has in operation a 1000-ton blast furnace (930 cu m capacity) and a 500-ton blast furnace, more recently installed, in which studies of oxygen enrichment have been made. The open hearth and electric furnace shops consist of relatively small 5 and 10-ton units, all quite old. There is also a new 10-ton converter in which experimentation with oxygen blowing is taking place.

Tula—large-scale experimental plant

This plant was the first in which large-scale experimentation was done with oxygen beginning in 1944. There exists a new high-pressure oxygen plant producing 10,000 cu m per hr, and on older low-pressure oxygen plant producing 14,000 cu m per hr of 98.5 pct pure oxygen. Argon and krypton are currently being recovered, and it is contemplated that nitrogen will also be recovered for use in a ferro-alloy plant to be built.

Continuous Casting: Of particular interest was the continuous casting (Junghans-Rossi type) program where full-scale experiments have been under way for several years. The largest section to be cast thus far is a section approximately 7x20 in. The freezing unit for this slab stands about 5 to 5½ ft tall, and consists of a rib-reinforced copper liner which is about 3/16 of an in. thick. During the experimental phases of this program, 19,000 tons of steel were cast in this freezer. Steel is poured into a tundish from which it is repoured into the freezing unit. The freezing unit moves a distance of about ¾ of an in. in a 2-second cycle to prevent sticking of the slab to the mold. Paraffin oil, found to give the best results, is added at the rate of 3 kg per 10-tons as a continuous operation.

More recently this entire structure was remodeled in order to cast two 9 in.-sq billets. Two billets of this size are poured simultaneously in order to empty the ladle within the shortest time possible to avoid severe skulling. The slabs are cut to length by oxygen-acetylene as they emerge below the pouring platform. Consideration is also being given to casting four 6-in.-sq billets simultaneously.

Radioactive tracer techniques have been used to establish the depth of unsolidified metal. It was noted, for example, that with a pouring rate of 90 cm per min, the 9 in.-sq billets have the last molten metal at a distance of 5 m below the liquid pouring level.

Thus far, transformer steels and plain carbon steels, including killed, semi-killed, and rimmed steels, have been successfully handled in this operation. Studies have been made of the effects of pouring temperature, pouring rate, and cooling water capacity to establish the kinds of structures that are desired for each different composition. Sections from semi-killed steels (9 in.-sq ingots) were observed in which the blowholes were seated from ¾ to 1 in. deep, leaving a dense skin which would be equivalent to the best rimming skins noted in conventional top-cast practice.

Plant-scale experimentation of this sort is possible in a controlled economy such as exists in Russia because the benefits from such full-scale industrial experiments are utilized throughout the entire industry. The cost of such prorams, spread through a 50 million ton industry, are more easily absorbed than if one company tries to carry the program.

Sverdlovsk—heavy-machinery plant

We flew to Sverdlovsk from Moscow, via Kazan, a distance of something over 1000 miles. We were surprised to find a city of one million people which boasts several heavy industries. The purpose of the visit was to see the industrial activities at Ural-

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mash, the heavy machinery plant in Sverdlovsk. This plant, like so many in Russia, is a completely integrated plant, having its own melting facilities, forging shops, machine shops, fabrication shops, etc. The steel capacity is only 150,000 tons, and all of this is used internally.

A fairly old open-hearth shop of four furnaces, all of the tilting variety, includes one 90-ton, one 60-ton, and two 30-ton furnaces. In addition there are six electric furnaces, all quite old and of small size, under 10-tons.

In addition to the steel shop, there is also a large foundry in which four of the electric furnaces are found, one of them being an 8-ton acid furnace. There is one cupola producing 8 tons per hr, and a second cupola being built which will produce 17 tons per hr.

Plain carbon and low alloy steels are produced, some stainless steels are made, and nodular iron, brass and regular foundry irons are all in production. The foundry takes 45 pct of the steel production and 55 pct goes into ingot production.

Vacuum ingot degassing: Of particular interest to us was the vacuum ingot degassing operation. For this purpose, there is a 120-ton ingot installation and a second installation for a maximum of 32 ton ingots. To handle the degassing, there is a nine-pump station working through a 10-in. manifold, which is capable of maintaining a vacuum of 3 to 8 mm of mercury in the mold chamber during the pour. The maximum pumping capacity of this set-up is 3800 cu m per hr, but three to nine pumps can be operated, depending on the needs. The arrangement is such that steel is poured from a transfer ladle into a holding ladle which is sealed to the top of the vacuum chamber. When the holding ladle is about half full it is opened up and the metal burns through an aluminum seal and pours into the vacuum chamber below. Pouring is done in vacuum but solidification takes place in air. A 1-½ in. nozzle is used and permits the pouring of 120-ton ingot in about 32 min.

In the forging department there is a 3000-ton press and another 10,000-ton press on which items such as metallurgical rolls, shafts, turbine rotors, rings, pressure vessels, etc., are made. It was commented by the Russians that they no longer make any turbine rotors at this plant from ingots which have not been vacuum degassed for removal of hydrogen.

Chelyabinsk—A post-war plant

Chelyabinsk is a somewhat smaller city south and slightly east of Sverdlovsk by a distance of about 150 miles. The steel plant has been in existence only since about 1941; it became an integrated steel producing unit in 1945. There are about 15,000 people working at the plant, which produces about 3 million ingot tons of steel per year.

This is a completely integrated steel mill including a coke plant of six coke batteries, and all of the facilities for handling, blending, washing coal, etc. The coke is delivered to the blast furnace by a belt arrangement.

There are four blast furnaces, the largest of which is a 1386 cu m capacity unit; two are of 1000-ton and two of 1700-ton per day capacity. These blast furnaces are completely instrumented and mechanized with a very modern control room operated by only one person. Measurements are constantly recorded of blast temperature, stock line, top pressure, humidity of the blast, etc. Charging is called for automatically from the control room. In 1945, a large sintering plant, consisting of two Dwight-Lloyd-type lines, was installed and a third line is currently being built.

The blast furnaces operate at a blast temperature of 780°C; humidity is controlled at 30 g of water per cu m. Top pressure is maintained at 1 atmosphere over-pressure. The blast furnace utilizes a charge which consists of 70 pct sinter and 30 pct lump ore containing about 55 pct iron. The silicon content of a typical tap is 0.6 to 0.7 pct.

There are two open hearth shops. Shop No. 1 was completed in 1953 and consists of five open-hearth furnaces which were originally built as 185-ton capacity units and have since been rebuit to 370-ton units. The second shop was initiated in 1941, and was finally completed in 1949. It consists of six open-hearth furnaces which were originally designed for 90-ton capacity and which are now operating at 180-tons. A large mixer ladle services the open hearth division. The product from these open hearth shops is almost exclusively carbon steels for intermediate weight structural products.

There are five electric furnaces in operation, all relatively old units, originally rated for 30-tons, but now operating at 40-ton capacity. They are of the door-charging variety. For melting and decarburization with oxygen, we noted that roof lances

Two of the eight blast furnaces and some workers at the 6½ million-ton Magnitogorsk integrated steel plant. These large furnaces are producing at the rate of more than 2000 tons per day from a charge made up of 85 pct self-fluxing sinter. They are operated at pre-heated temperature of 830°C. Sovfoto.

were being used. Temperatures are taken by means of thermocouples. Tungsten-molybdenum thermocouples were in use at the time of our visit, but we were informed that they prefer to use the platinum-platinum rhodium couples for many reasons. The devices used for inserting the thermocouples were quite similar to those used in the US.

The open hearth furnaces operate at 63 to 65 pct hot metal, with a production rate of 23 tons per hr. Very large charging boxes are used to speed up the charging. The pit side of the furnaces is crowded because of the doubling of the melting capacity in both instances. On the other hand, the charging side of the open hearths is spacious with plenty of room.

Here, as in 90 pct of all of the open hearth facilities in the USSR, chrome-magnesite roof brick is used. At this plant they claim 550 heats per roof for the larger, and 600 for the smaller furnaces.

Magnitogosk—A 6.5 million ton plant

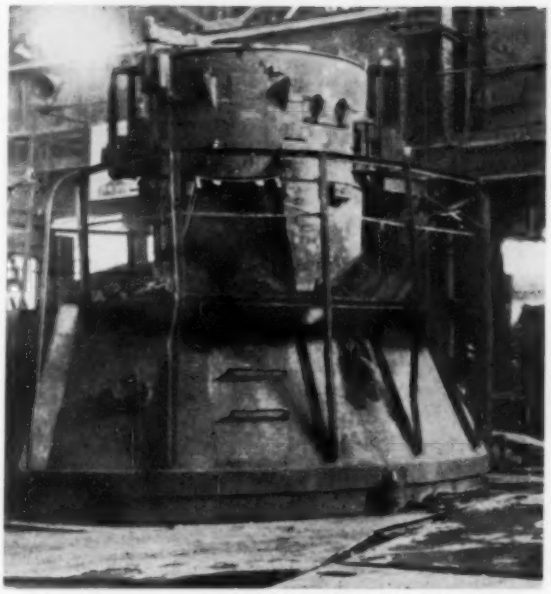
Our third visit in the Ural region was to the steel plant at Magnitogorsk, a town of about 300,000 people. The production capacity of this plant is 6½ million ingot tons per year. There are eight blast furnaces, seven of which have fire-brick in the hearth and one of which is operating with a carbon hearth. The carbon hearth has operated for only a period of three years; as a result, there is no measure yet of its usefulness in comparison to the fire-brick hearths. The blast furnaces in this plant are very large, producing of the order of 2000+ tons per day, with an annual production rate of about 750,000 tons. Plans are underway to achieve an annual rate of 1,000,000 tons per furnace. The blast furnaces run on an 85 pct sinter charge, with a 15 pct sized lump ore addition. The sinter is made into a self-fluxing mix. Enough lime is added to the sinter to correct even for the ash in the coal. The coke rate is about 1400 lb per ton of iron, and slag volume is about 600 to 700 lb per ton of iron for these furnaces.

The sinter plant, a very modern Dwight-Lloyd set-up, consists of three plants of four lines each, with a production rate of 2000 to 2500 tons per belt per day. Because this is a self-fluxed sinter, about 15 pct of the product is returned as fines to be resintered. The ores are blended to control sulfur content, and the iron content of the final sinter product runs between 44 and 46 pct. On occasions, as much as 88 to 89 pct sinter has been used in some of the blast furnaces.

The blast furnaces operate on a preheat temperature of 830°C (compared to only 560°C in 1950). Here, as at Chelyabinsk, the blast furnaces are all top pressure units operating with humidity control.

The pig iron from these blast furnaces is of particular interest because of its very low manganese content, about 0.15 pct. No effort is made to increase this value. The sulfur content averages 0.035 pct, but runs as low as 0.021. The silicon content normally averages 0.8 to 0.9 pct. A typical slag composition was noted to be 40 pct CaO, 45 pct SiO_2, 8.5 MgO, and 16 pct Al_2O_3. The sulfur content of this slag was 1 pct.

The open hearth shops numbered three altogether. One of these consists of only three 250-ton capacity furnaces. This shop will, however, be enlarged through the addition of six 500-ton furnaces which are due to be installed in the immediate future. The other two open hearth shops consist primarily of 400 and 200-ton furnaces, although most of these



The 120-ton vacuum treatment chamber in Ural heavy machinery plant in Sverdlovsk. Pouring is done in vacuum, but solidification takes place in air. A 1½ in. nozzle permits pouring of a 120-ingot in 32 min. Photograph by Professor John Chipman of MIT.

are of the 400 ton variety. The production rate of the 400-ton furnaces is about 30 tons per hr.

Hydrogen control in the open hearth is exercised primarily by making sure that all additions are dry, and all ferro-alloys are dried and preheated before charging.

Here, as at Chelyabinsk, we again noted the use of the very large charging boxes. Again, because this is a very new plant, the amount of floor space was large with no evidence whatsoever of crowding.

The addition of the six 500-ton furnaces will be easy to accomplish, since the Magnitogorsk plant has a large excess capacity of pig iron, producing about 5½ million tons of pig iron per year. It is planned that in the next seven years this plant will have an annual production of 10 million ingot tons. A large oxygen plant is projected.

We were informed that there is a rather large research laboratory at this plant which employs about 800 people.

General comments

Coke shortage: It appears from discussions with steel mill people that the coal and coke problem in Russia is of maximum seriousness because of the lack of really good coking coals. For this reason, every effort is made to decrease coke consumption through such means as using large quantities of sinter in their blast furnace charge.

Blast furnaces: The equipment and facilities which we saw in these visits were all of very high quality. The technological accomplishments are also considered to be very high grade. As a general observation, we would conclude that the Russians have built blast furnaces which are probably at least as good as our best. They have applied more of the innovations than we have; in fact, their gains may be greater because they have applied more than one innovation in any one furnace. For example, in addition to pressurized operation, they are using higher preheat temperatures, considerably

higher sinter charges, humidity control, and they will use oxygen enrichment as soon as the oxygen plants can be built.

The benefits are, of course, frequently better than additive. Their larger production would indicate that the benefits are quite real. As an example of new things that can increase yearly production, the time required to replace a complete blast furnace shaft was drastically cut by use of a *movable blast furnace shaft*. A complete working model is on display at the Industrial Fair in Moscow. The new furnace shell was erected on a trestle about 80 ft from the old furnace. When the old furnace was dismantled, the new shell weighing 2500 tons was moved into place in about 12 hr. The total down time was said to have been 40 days in comparison with the usual 6 months. It is reported that the method has been used successfully at the Kuznetz Metallurgical Plant and at Dniepropetrovsk.

Open hearth: In terms of open hearth comparisons there is little to choose. We believe that their open hearth operations are in line with our own. The Soviets, particularly in the Siberian area, find scrap very difficult to get and must rely on larger hot metal charges. The very extensive use of the chrome-magnesite suspended roofs would indicate an ability to run slightly hotter than the average American furnace, as was suggested by the Russian engineers.

The new open hearth furnaces being installed in the USSR will be more and more of the 500-ton variety because of apparent economies evident in their system. This would mean that the average open hearth furnace size is larger in the USSR than in the US.

In the three Siberian steel plants we visited, tar and pitch plus enriched coke-oven gas are the common fuels. Oil and natural gas have not, as yet, been generally available in these areas, although there is some thought that pipe lines will come into this region in the future. Other areas are somewhat more fortunate in this regard.

Electric furnaces: In terms of electric furnace production, it is quite obvious that the Russians are considerably behind American practice. In part this may be due to the unavailability of electric power, and, in part, possibly to smaller demands for electric furnace products.

Continuous casting: It is obvious that the Russians will put considerable pressure behind two developments. The first is continuous casting, because of the anticipated savings of time and costs, as compared to building large blooming mills; and secondly, in the use of oxygen to a greater extent because of increased production rates.

There are currently four continuous casting units in existence, of which two are in full-scale operation. An estimated 100,000 tons have been cast to date.

From what we have seen, we think that the Soviets have been doing extremely well in the application of the principles of steelmaking, in the installation of modern equipment, and in the utilization of manpower for production purposes.

Alloyed Steel in the Ukraine

In the Ukraine, David Swan, as a part of the 11-man metallurgical exchange group to the USSR, recently visited a large special-steel plant and a ferroalloy plant.

as told by David Swan

THE Dnieperprestoye steel works, which employs 10,000 persons, is an electric-furnace steel plant which manufactures all types of stainless and alloyed steels. Capacity is claimed to be over 1 million ingot tons from two melting shops, one comprising three 25-ton electric arc furnaces and a second of five 40-ton furnaces*Capacity actually appears closer to 500,000 tons. In the former, all three furnaces are making 18 Cr, 8 Ni-Ti bearing stainless steel. Table I provides a comparison between steelmaking at this plant and general American practice.

Ingot preparation similar to US practice

All stainless steel ingots were cooled for scarfing before rolling. The principal method of scarfing comprises overall turning of the skin about ½-in. deep on a 24-in. sq ingot. Special lathes are in use, each with four cutting tools. This method of surface preparation results in a 4 to 5 pct metal loss. Deep-seated defects are removed by spot chipping.

Heating furnaces are gas or oil fired and similar to American construction. They are well instrumented with automatic recorders for temperature. Break-down rolling appeared to be similar to American practice, and the rolling equipment was partly of German construction and partly of Soviet construction. After rolling, billets are allowed to cool, and further conditioning is carried out either by spot grinding or by means of rotating tools, similar to the American *Billeteer*. Very little abrasive-wheel grinding appeared to be used, and the Russians stated that abrasives do not perform satisfactorily for heavy steel mill use.

Particularly noteworthy in this steel mill is the complete absence of even elementary safety precautions. Goggles are worn only rarely, even when grinding or chipping. When I asked if the men wore safety shoes, the superiors did not appear to know what safety shoes were.

Research and development facilities

A large research and development unit forms part of the plant. Much of the work of this laboratory has little to do with the day-to-day operating problems. Among the laboratories are the physical test-

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ing lab with a low temperature tensile machine suitable for work down to −60°C, seven creep machines, five fatigue testing machines of the rotating beam type; a radioisotope laboratory; a well-equipped X-ray laboratory; a dilatometric laboratory; a laboratory for making magnetic measurements; and several chemical analytical laboratories. A total of five spectrographs were observed.

The plant is closely allied with Zaporzhe Stal, which is a fully integrated steel mill nearby. All alloy and stainless flat products were rolled at this works, which we did not visit.

Zaporozhe ferroalloy works

The Zaporzhe ferroalloy plant was started in 1933 and completely destroyed by the Germans during World War II. It was rebuilt in 1948, and now there are 2000 employees and three electric furnace shops, one for ferrosilicon and silicomanganese, another for low-carbon manganese metal and a third for low-carbon ferrochrome. The plant has 150,000 kva transformer capacity and is one of at least three ferroalloy plants in the USSR.

Ferrosilicon: The ferrosilicon shop comprises six three-phase arc furnaces, plus two new furnaces which are being installed. The furnaces are similar in appearance to American submerged-arc ferroalloy furnaces, each being of 10,000 kva transformer capacity with a 6.5 m diam shell. Soderberg electrodes are employed. A charging machine similar to those found in steel works is used, and each furnace has two such machines on circular tracks around the circumference of the shell. Furnace covers are not used to keep down dust and fume. Power consumption is 4400 kw-hr per metric ton of 45 pct ferrosilicon and 8600 kw-hr per metric ton of 75 pct ferrosilicon. Carbon consumption is 23 kg per metric ton of the 45 pct alloy and 35 kg per metric ton of the 75 pct alloy. Ferrosilicon is ladle tapped and poured into a cast-iron shell 1x2.5 m by 100 mm thick. Stated cost of the 75 pct ferrosilicon is 926 rubles per metric ton.

Manganese: The manganese shop comprises four 3000 kw open arc furnaces, 3.5 m in diam, for making 97 pct manganese metal. Furnaces are of typical tilting design using graphite electrodes. The process consists of refining manganese ore with silicomanganese to produce manganese metal and a high-manganese slag, which is subsequently submerged-arc smelted to standard ferromanganese to improve overall manganese recovery from ore. The furnace is lined with magnesia brick. Power consumption is 13,000 kw-hr per metric ton.

Ferrochrome: The ferrochrome shop has five 3500 kva furnaces for making low-carbon ferrochrome. Each furnace is 2.5 m in diam. The process comprises smelting 52 pct Cr_2O_3 ore of a 3:1 chrome: iron ratio with FeCrSi of 50 pct Si and 30 pct Cr.

There are two unique features of the process: First, the low-carbon ferrochrome is tapped into an unlined ladle which contains a layer of slag retained from the previous heat, thus achieving economy in refractory usage. Second, all low-carbon ferrochrome produced is vacuum degassed. We were told that total gas content was decreased from 27 to 44 cc per 100 g to the range of 2.5 to 7 cc per 100 g.

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Table I. Comparison of American and Soviet Electric Steelmaking Practices for 18-8 Stainless

		Soviet (18-8 Ti)	U. S. (18-8)
A Equipment			
Heat size, tons		25	25
Shell size, ft diam		15	13
Transformer, KVA		10,000	7000
Voltages		—	225 Top
Electrode usage, lb per ton		16 to 17	11 to 14
B Refractories			
Roof	Type	Chrome-Magnesite	Silica or Alumina Bricks
	Life	120 Heats	125 Heats
Bottom	Type	Rammed Magnesite	Rammed Magnesite
	Life	2500 Heats	1000 to 3000 Heats
Side Wall	Type	50 pct MgO:50 pct Dolomite Cast	Chrome-Magnesite Brick
	Life	150 to (?) Heats	150 to 200 Heats
Furnaces are overcharged by 30 to 50 pct of their normal rated capacity.			
C Furnace Practice		2 Slag	2 Slag
1. Meltdown			
Charge		70 pct Stainless Scrap, Steel Scrap	40 pct Stainless Scrap, H.C. FeCr, Steel Scrap
Cr, pct		12.5	10
C, pct		est 0.5 to 0.7	0.3
2. Decarburization		Oxygen	Oxygen
Time of blow, min		20	45
Pct C—end of blow		0.2 to 0.3	0.05
Temperature—end of blow		est—less than 3100°F	3200 to 3400°F
Cr + Fe + Mn oxidized/ton		est—very low	100
3. Reduction Period			
Reducing agent		75 pct FeSi + CaSi	FeCr-Si
Cooling scrap		No	Yes
Reladle		No	Yes
4. Finishing Period			
Slag		CaO + Al_2O_3 + MgO	CaO + SiO_2
Additions		L.C. FeCr, Ni, L.C. FeMn, FeSi	L.C. FeCr (Max 0.06 pct C), Elect Mn, FeSi, Ni
Final sulfur, pct		0.005 to 0.010	0.010 to 0.015
5. Totals			
Time (charge to tap), hr		4 to 4.5	4 to 4.5
Power Kw-hr per ton		650	560
Chromium recovery		95	95

A High-Temperature Centrifuge For Creep, Rupture, and Bend Tests

One of the most interesting results of the visit by several Russian metallurgists to the World Metallurgical Congress was disclosure of the successful use of a high-temperature centrifugal testing apparatus. The device is here described by its designer, a prominent Soviet metallurgist.

by I. I. Kornilov

EXTENSIVE study of the mechanical properties of metals at high temperatures, especially creep and long-time rupture, and their dependence on composition, has been limited by the complexity of testing, the expense of long-time tests, and the large number of specimens required. New methods of investigation have been developed which are simpler than those previously existing. Hot hardness techniques have already been proposed and applied by A. A. Bochvar[1,2] and other authors.[3,4] The centrifugal method proposed by the author[5] is based on the application of centrifugal force for studying creep and rupture of metals at high temperatures.

For rapidly rotating specimens, the centrifugal force is determined from the formula

$$P = m\,r\,w^2,$$

where m is mass, r is radius, and w is angular velocity. Two methods were used in applying centrifugal force to the study of plastic flow in metals: 1) deformation in bending, and 2) deformation in tension. Both methods are equally applicable to the study of plastic properties of metals at high temperatures, but practical work showed that the study of deformation by bending is simpler and more useful. This method permits the simultaneous testing of a large number of specimens 100 mm long, 3 to 4 mm diam, and weighing 5 to 10 gm at temperatures up to 1200°C.

Machine tests 24 specimens

One of the models of the machine for centrifugal testing in bending is shown in Fig. 1.[5,6] This may be modified according to the different techniques used. It is of the laboratory type and permits simultaneous testing of 24 specimens. In this apparatus one can carry out tests for small amounts of deformation, corresponding to creep conditions, as well as tests of the long-time rupture strength. The disc in the testing machine may be rotated at up to 4000 rpm, but in practice it is used in the range of 1000 to 3000 rpm. If a load is fastened to the free end of the specimen, stresses up to 70 kg per sq mm are obtained. This is high enough for tests of materials with a wide range of strengths in bending.

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For studies of bending strength, deformation is obtained in the following way: twenty-four identical specimens are placed vertically in a grip at the end of the rotating member. With constant radius of rotation and a constant rate of spinning, a constant rotating torque is obtained according to the centrifugal force formula. During the initially constant conditions of stress, the specimens bend with time either rapidly or slowly.

For a given specimen, the deformation is measured by the bend deflection as a function of the time t. Observations on a large number of specimens yield bend deflection vs time curves with different deformation rates as shown in Fig. 2.

Specimens low in strength begin to deform at the start of the centrifugal stressing, and in a very short time are deformed to the maximum bend angle, Fig. 2, curve 6. All other specimens lie in a position intermediate to curves 0 and 6 according to their different strengths.

Stress conditions

The stress under these test conditions is constant in the initial period of rotation and for small deformations. The force of bending changes with increased bending, the change being proportional to the change in rotational radius. Under these conditions of deformation, weak materials are subjected to more severe bending on account of the increasing centrifugal force, and the deformation rate is even higher than in the initial period. However, it was established that specimens of different strengths bending at different rates arrive at the same stress condition at different times. Therefore, the bend specimens have the same stress for the same degree of deformation. Specimens of different strength then experience equal bending forces; thus, the time to reach a fixed deformation is a measure of the relative strength of the alloys studied. Strength is defined, then, as the time to reach a given deformation determined by the crossing of the bend vs time curve by a straight line parallel to the abscissa, Fig. 2.

Use of the centrifugal method

Twenty-four or more similar specimens differing in chemical composition or thermal treatment are tested under the same conditions of temperature

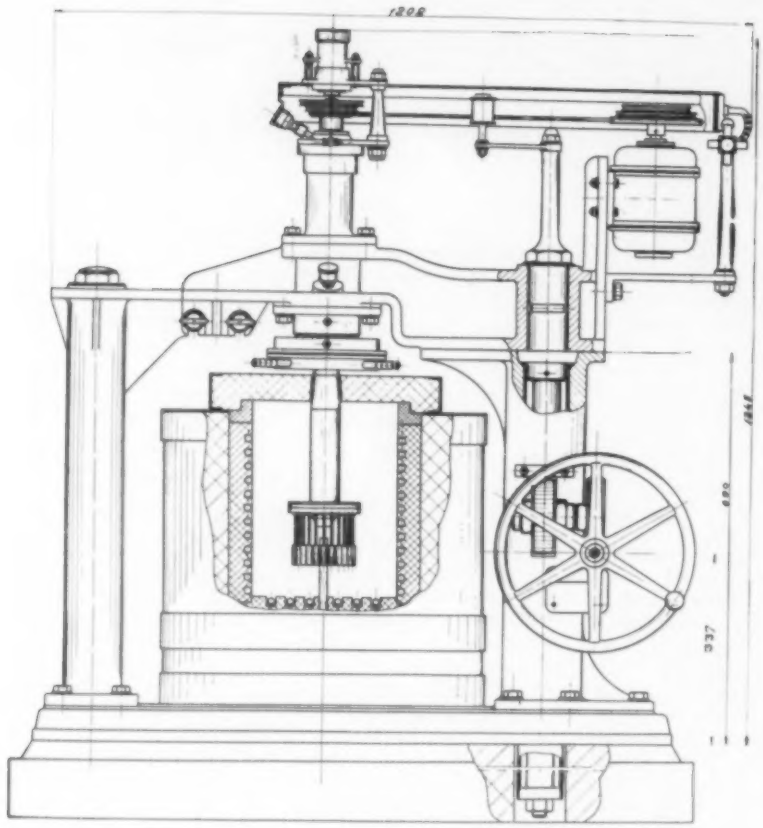

Fig. 1—General view of the centrifugal testing machine. In this apparatus tests for small amounts of deformation, corresponding to creep conditions, as well as tests of the long-time rupture strength can be carried out.

and initial stress. The relative strength is studied by periodically determining the amount of bending. Ordinary methods are used for measurement of the bend after cooling the specimens. The amount of bending is determined after 15 and 30 min, and 1, 2, 5, 10, and 50 or more hours. The magnitude of bending can be used for construction of time vs deformation curves in relation to composition and other factors of the alloy.

The apparatus permits the utilization of small specimens tested under laboratory conditions for

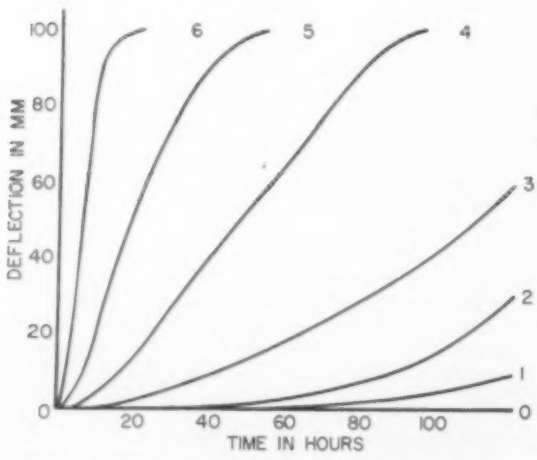

Fig. 2—The time-deformation curves for alloys of different strengths. Low strength specimens begin to deform at the start of centrifugal stressing.

1) Studying the strength of metallic systems over a wide range of concentrations—the results of these studies permit the construction of composition vs property diagrams; 2) Studying the influence of temperature and other factors on the rate of deformation of alloys, and determining the temperature coefficient of the strength of metals and alloys over a wide range of temperatures; 3) Studying the influence of thermal treatment, grain size, and other engineering factors on the same alloy and dispersed phases and their agglomeration in relation to hardening and softening of alloys; and 4) Finally, for determining the ductility or brittleness of alloys. Ductile alloys bend either rapidly or slowly to significant amounts. Brittle specimens break with little or no deformation at all.

Typical experimental information

In the past 10 years the centrifugal method of strength testing has given a large volume of experimental data, both for room temperature and elevated temperature, as well as for short time tension and long-time tests of 5000 to 10,000 hr.

The method has been directed to the question of regularity of variation of the strength of metallic systems with the type of phase diagram. Detailed work has been carried out on nickel systems. The dependence of strength on composition has been studied for the systems Ni-Cr, Ni-Al, Ni-Ti, and Ni-W,[7-10] as well as for more complex systems.[11-18]

Here we will present limited data on the system Ni-Cr for 800° and 1000°C, where the initial stresses were 12.3 kg per sq mm and 2.7 kg per sq mm repsectively.

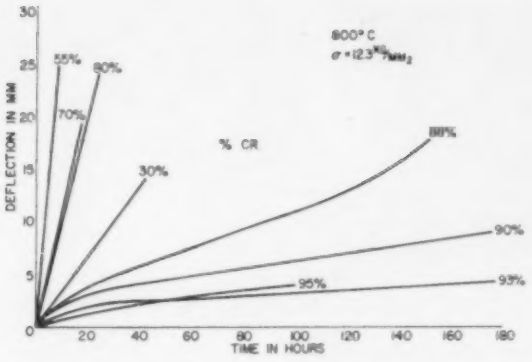

Fig. 3—The time deformation curves for nickel-chromium alloys at 800°C.

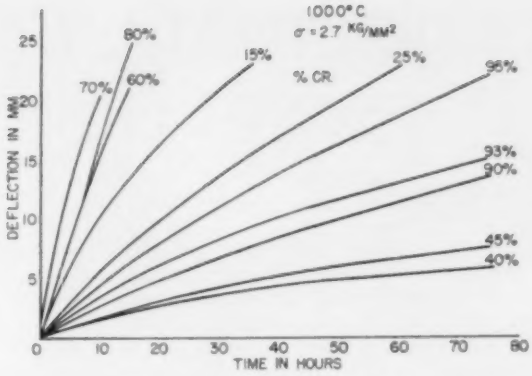

Fig. 4—The time-deformation curves for nickel-chromium alloys at 1000°C.

Figs. 3 and 4 show curves of bend deformation vs time for different alloys. From these data, Fig. 5 was constructed showing the strength-composition diagrams for these two temperatures. The strength is shown as the time to reach a bend of 5 mm. In the upper part of Fig. 5 is shown the Ni-Cr phase diagram and below the composition-strength diagrams for 800° and 1000°C. As is apparent, both curves show two maxima. These maxima correspond to the compositions of the solubility limits of chromium in nickel and of nickel in chromium. Concerning the details of these maxima, the height of the maximum is different for the two ends for the two temperatures. At 800°C the maximum strength of the chromium alloys is higher than of the nickel alloys. The maximum life is 240 hr for the chromium alloys and 45 hr for nickel alloys. At 1000°C the picture is reversed; such differences are related to the differences in crystal lattice of nickel and chromium.

Summary

1) The centrifugal method for studying the strength of alloys in bending is an important method for investigating the regularity of the variation of strength with composition and structure at different temperatures.

2) The centrifugal method is useful in studying the influence of chemical composition, structure, thermal treatments, and other factors on the strength of metals at one temperature.

3) The maximum temperature attainable is 1000° to 1200°C and stresses up to 100 kg per sq mm are permitted. The time of test is not restricted.

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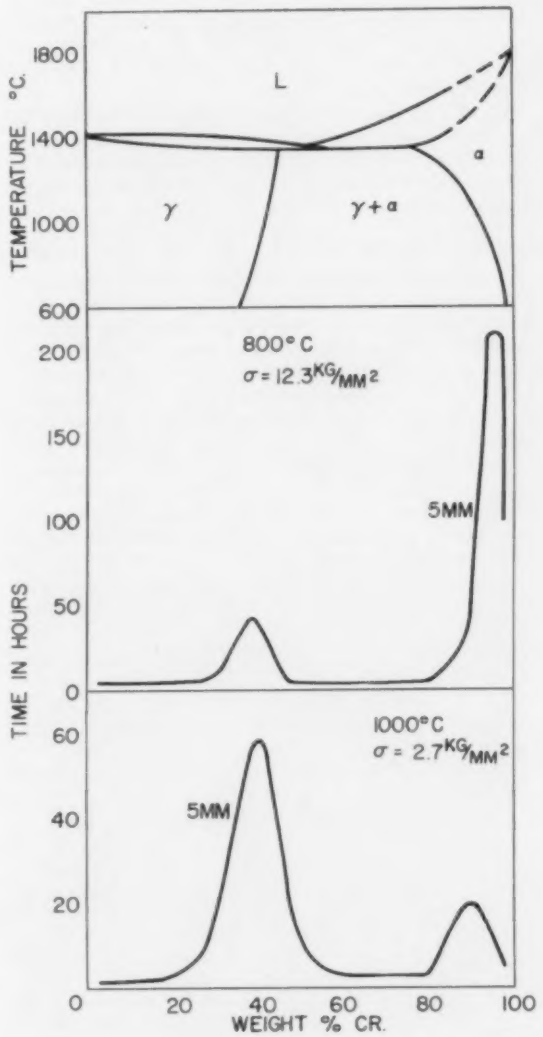

Fig. 5—The constitution diagram for the Ni-Cr system and the strength-composition diagram for the same system at 800°C and 1000°C.

VACUUM TREATMENT OF STEEL IN THE SOVIET UNION

A report of recent work at the Yenakievsky, Dzerzhinsky, and Dnieprospetsstal plants, describing the effect of vacuum treatment on the composition and properties of certain steels.

by A. M. Samarin

SINCE we cannot rely on making steel in millions of tons in vacuum furnaces in the near future, other arrangements providing large-scale production of steel with minimum oxygen, nitrogen, and hydrogen is one of the most important tasks of modern metallurgy.

In 1940, a new method of utilization of vacuum in steelmaking was proposed[1]. This consists of subjecting liquid steel produced in any steelmaking furnace to vacuum treatment in a ladle placed in a special chamber, or during casting in molds.

Origin of new method

In studying evolution of gases from chromium-nickel constructional alloy steels produced in 30-ton electric arc furnaces, the liquid steel was teemed into 1200 kg ingot. The gases evolving from the steel during teeming and solidifying were collected in a gasholder, as shown in Fig. 1.[2] Separation of gases was observed at atmospheric pressure, which was maintained by discharging water from the gasholder at a definite speed. Occasionally, because of rapid water discharge from the gasholder, pressure above the steel surface in the ingot mold became lower than atmospheric, causing the well deoxidized steel in the mold to boil; in other words, the fall of pressure caused faster gas removal from the liquid steel. These observations served as the basis for the proposal to use vacuum for treating liquid steels in order to decrease their gas contents.

Vacuum treatment of converter steel

At the Yenakievsky metallurgical plant, bessemer steel was subjected to vacuum treatment in a 16-ton ladle and in a 4-ton ingot mold. Three melts of rail steel and seven melts of other steel were treated, in the ladle, and seven melts of rimmed steel were treated in the ingot mold[2].

Because of intensive boiling of steel in the ladle, it was impossible to maintain low residual pressure; therefore, the pressure varied within the limits of 70 to 100 mm Hg. Steel in the ladle was exposed to vacuum for 12 to 14 min and that in the ingot mold for 25 to 30 min. After the exposure, steel from the ladle was teemed in air.

A. M. SAMARIN is with the Institute of Metallurgy, Academy of Science, USSR. This paper was presented at the Vacuum Metallurgy Course, New York University, June 1957, and will be published by Rheinhold Publishing Co. in *Vacuum Metallurgy*, R. F. Bunshah, ed., in 1958.

Vacuum-treated rimmed steel in the ingot mold behaved like deoxidized steel and solidified with visible shrinkage. The ingots were rolled to produce billets 13x19x350 mm in size. In order to compare the properties of the experimental and ordinary steel, segregation of sulfur was studied, and oxygen and nitrogen content was determined. For this purpose two ingots of rimmed steel, one cast from the ladle treated in vacuum and the other in the mold, were cut in the longitudinal direction.

A short exposure of converter steel to vacuum was found to affect a four to ten-fold reduction in oxygen content. In the steel of some heats, this content decreased the range of 0.004 to 0.005 pct, which is characteristic of a deoxidized steel. The oxygen content in the steel subjected to vacuum treatment is two and a half to five times lower than in the steel which was not treated in vacuum.

Vacuum-treatment influenced the purification of the steel from nitrogen to a lesser extent. The vacuum-treatment of liquid steel in the ladle reduced its nitrogen content by 30 to 50 pct.

A photograph of the sulfur print taken from the longitudinal section of the ingot of rimmed steel treated in vacuum is shown in Fig. 2. In contrast to the ingots of ordinary rimmed steel, no gas bubbles were found in the ingot cast from vacuum-treated steel. As a result of chemical analysis, it was established that carbon, sulfur, phosphorus, nitrogen

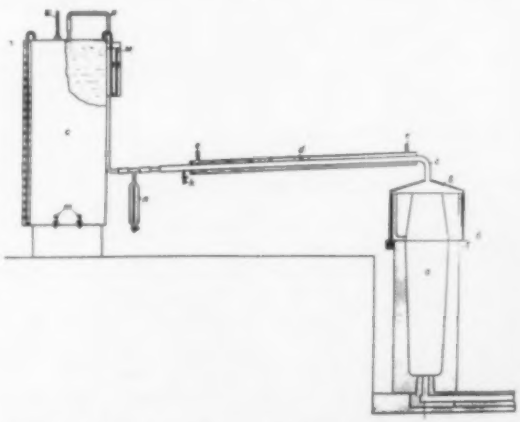

Fig. 1—Gasholder used in early studies for collecting gases from steel during teeming and solidifying.

Fig. 2—Sulfur print of the longitudinal section of an ingot of rimmed steel treated in vacuum. No gas bubbles were found, and C, S, P, N, and O distribution was very uniform.

and oxygen distribution in the ingot was very uniform.

Fig. 3 shows sulfur prints of the rolled stock obtained from an ingot cast from rimmed steel treated in vacuum (right), and from an ingot cast from ordinary rimmed steel (left). It should be noted that a rolled stock with very little segregation was obtained from the vacuum-treated ingot.

At the Dzerzhinsky plant: The change of hydrogen content in converter steel resulting from vacuum treatment in a ladle was studied at the Dzerzhinsky plant. Here, when producing rail steel, blowing of pig-iron in a bessemer converter is stopped at a high carbon content, and then the metal is deoxidized and cast into molds. For treating a ladle with liquid metal in a vacuum chamber, the steel is poured from the converter into the ladle which then is placed in the chamber. In 4 or 5 min the pressure in the chamber is reduced to 2 to 10 mm Hg. The total exposure of ladle in the vacuum chamber does not exceed 15 min. After vacuum treatment the ladle is taken out of the chamber, and the steel is cast into molds in air.

Table I gives the data concerning the change of hydrogen content in bessemer rail steel resulting from its treatment in a vacuum chamber. Steel samples for determination of hydrogen content were taken from the ladle both before and after vacuum treatment of liquid steel. It was found that a short exposure of bessemer steel to vacuum provides more than twofold reduction of hydrogen content.

Before vacuum treatment, the steel was deoxidized by manganese and silicon, and some melts by

Table I. Change of Hydrogen Content in Rail Steel During Vacuum Treatment

Time of Exposure, Min	Pressure, Mm Hg	H_2 Content, Cu Cm per 100 G	
		Before Vacuum Treatment	After Vacuum Treatment
10	9	6.8	4.1
11	11	4.2	1.8
9	3	3.4	2.6
12	3	7.0	3.5
11	4	1.9	1.1
10	4	2.1	0.7
13	7	2.9	2.0
14	2	4.0	1.7
14	2	4.4	1.5
13	6	3.8	2.2
14	6	7.6	3.0
14	6	6.1	3.0
14	8	6.4	2.3
11	9	3.3	1.8
12	11	5.9	2.0

Table II. Influence of Vacuum Treatment on the Change of Oxygen Contents in the Converter Rail Steel

Before Vacuum Treatment, Pct	After Vacuum Treatment, Pct
0.0038	0.0009
0.0054	0.0009
0.0071	0.0011
0.0039	0.0009
0.0046	0.0014
0.0030	0.0012
0.0040	0.0010
0.0050	0.0013
0.0046	0.0009
0.0067	0.0015
0.0056	0.0010

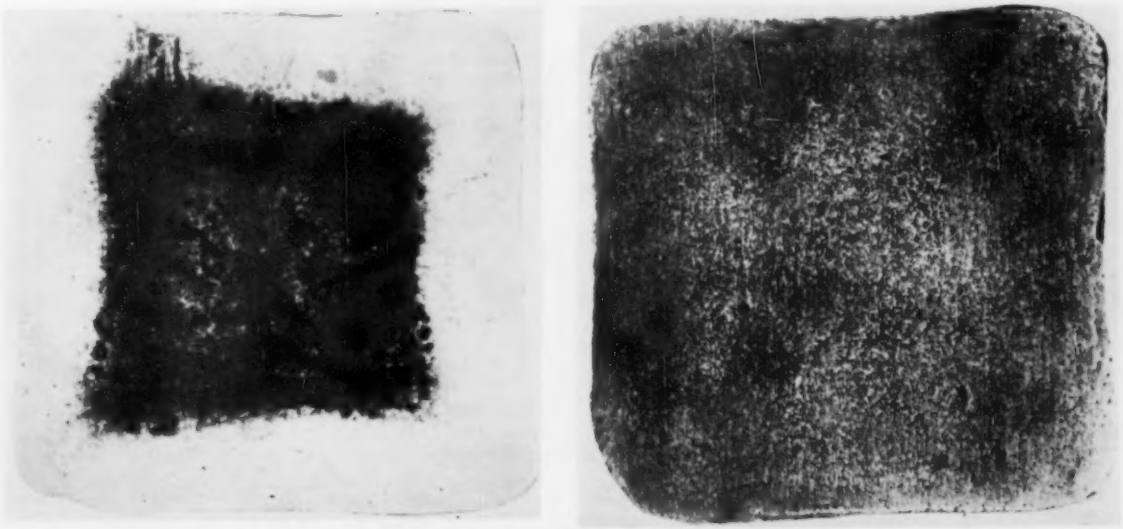

Fig. 3—Sulfur prints of rolled stock obtained from an ordinary rimmed steel ingot (left) and one treated in vacuum (right). The lack of segregation in the vacuum-treated ingot is obvious.

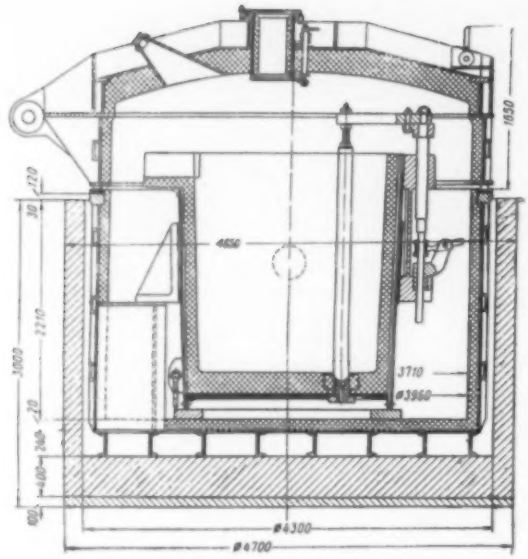

Fig. 4—Design of the vacuum chamber used in treating electric furnace alloy steels at the Dnieprospetsstal plant.

manganese, silicon, and aluminum. Nevertheless, as is shown in Table II, vacuum treatment in a ladle resulted in a noticeable reduction in oxygen content in the rail steel.

Vacuum treatment of alloy steel

At the Dnieprospetsstal plant, vacuum chambers are used for treating alloyed steels melted in 25-ton arc furnaces. Design of the chamber is shown in Fig. 4.

A ladle filled with liquid steels is placed in the chamber and kept there for 10 min under the pressure about 30 to 35 mm Hg. The chamber design allows pouring of steel from one ladle into the other placed in the chamber under vacuum.

Before vacuum treatment of liquid steel was introduced at the Dnieprospetsstal plant, it was found that the transformer steel melted in vacuum induction furnaces was distinguished by lower watt losses and by increased plasticity.[4] Therefore, vacuum treatment of liquid metal at this plant was used first and foremost in production of transformer steel. The improvement of electric properties of the transformer steel, all other conditions being equal, is due to reduction in its content of carbon, sulfur and oxygen. When steel is produced in arc furnaces, it is possible to provide low content of these impurities by increasing the temperature of the liquid metal. But casting of overheated steel often results in unsound ingots. As a result of vacuum treatment, unsound ingots were completely eliminated; therefore, it became possible to effect melting in the furnaces under higher temperatures.

Table III contains data on distribution of the transformer steel heats according to the carbon and sulfur content before and after the plant used vacuum treatment of this steel, determined in the samples taken from the ladle before casting into molds.

Almost all the transformer steel not treated in vacuum contained 0.04 to 0.09 pct C and not less than 0.007 pct S. Owing to vacuum treatment of liquid steel, almost all steel produced contains not more than 0.03 pct C and 0.003 to 0.005 pct S.

The transformer steel treated in vacuum is also characterized by the lower oxygen content (in the samples taken from the ladle the oxygen content is equal to 0.004 to 0.005 pct). It is possible to consider that, owing to vacuum treatment, oxygen content in the transformer steel is two or three times lower than its content in ordinary steel.

The reduction in carbon, sulfur, and oxygen content of transformer steel contributes to considerable improvement of steel plasticity and makes possible cold rolling with higher content of silicon. Also, the watt losses were decreased by 20 to 25 pct.

The tendency of chromium-nickel construction steel to form flakes and hair cracks can be essentially eliminated by decreasing the hydrogen contents of these steels. The Dnieprospetsstal plant subjected construction steels of different composition to vacuum treatment in the same chambers in which the transformer steel had been treated. Of 50 heats which had not been treated in vacuum, 35 had hair cracks, while of 41 heats of vacuum-treated steel only 13 had hair cracks. Moreover, the quantity and total length of the hair cracks found in the steel treated in vacuum were one and one-half to two times less than in the steel which had not undergone vacuum treatment. Good results were also obtained in vacuum treatment of chromium stainless steels.

It should be noted that, owing to the mixing of metal with slag, vacuum treatment of liquid steel in a ladle provides additional purification of steel from sulfur. This also causes more complete chromium reduction from slag in production of stainless steels.

Conclusions

Installations for vacuum treatment of liquid steel in a ladle are very simple; therefore, it may be expected that they will be wide-spread in metallurgical plants and used for treating steels on a high tonnage basis.

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Table III. Influence of Vacuum Treatment on the Carbon and Sulfur Content in Transformer Steel

Steel	No. of Heats	Distribution of Heats According to C and S Content: Max Carbon, Pct					Max Sulfur, Pct					
		0.01	0.02	0.03	0.04	<0.05	>0.004	0.005	0.006	0.007	0.008	0.010
Not treated in vacuum	144	—	—	3	32	65	—	—	6	35	42	17
Treated in vacuum	199	2	75	20	2	1	43	52	3	2	—	—

CONSUMABLE-ELECTRODE VACUUM ARC MELTING

Demands for new metals and alloys of higher purity are increasing the importance of vacuum melting in general and the consumable-electrode process in particular. Herein is a report on this phase of vacuum metallurgy, by a member of one of the leading European firms in the field.

by Helmut Gruber

CONTROLLED atmosphere arc melting dates back to 1839, when Robert Hare[1,2] described such a furnace before the American Philosophical Society. In 1902, the first consumable-electrode furnace was reported by W. V. Bolton,[3,4] who melted tantalum electrodes in a water-cooled metal crucible under a reduced argon atmosphere.

In the intervening years, the consumable-electrode vacuum arc furnace has reached a high state of development, significant contributions having been made by W. J. Kroll,[5] R. M. Parke and J. L. Ham.[6,7] S. A. Herres, and J. A. Davis,[8] as well as such organizations as Climax Molybdenum, the U. S. Bureau of Mines, Titanium Metals Corp. of America, and Allegheny Ludlum. At present, nations engaged in concentrated improvement of the vacuum arc melting process include, France, Germany, Great Britain, the US, and the USSR.

Technology of vacuum melting

Implicit in the development of consumable-electrode melting is the fact that graphite electrodes or electrodes made of some other non-consumable material show two fundamental handicaps:

(A) Non-consumable electrodes cause a certain pick-up of impurities. Consequently, it is desirable to do away with all electrode materials other than the metal to be melted. The melting of titanium and zirconium is a typical example, for the use of graphite electrodes always leads to lower corrosion resistance than is obtained by consumable-electrode melting.

(B) Non-consumable electrode furnaces must be operated at pressures higher than 5 mm Hg, whereas the consumable-electrode allows for pressures as low as technically obtainable. To stabilize the arc, a certain metal vapor pressure and a certain concentration of metal vapors in the arc zone is called for, but this is easily satisfied by high current ratings and a short arc length which is not practicable in arcs of non-consumable graphite electrodes.

Contrary to ordinary arc furnaces where crucibles with a refractory or graphite lining are used, all modern vacuum arc furnaces are operating on water cooled metallic crucibles and, in general, on copper crucibles. These copper crucibles are compulsory for the more refractory metals to avoid crucible damage and, particularly, contaminations by the crucible material. The minor surface contaminations the ingot is likely to get from the crucible metals are of no importance.

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Furnace design

Fig. 1 shows the design of a consumable-electrode vacuum arc furnace. The long stinger rod passing through a dynamic seal into the furnace chamber carries the electrode. A dynamic seal is a multistage lead-through from atmospheric pressure into the vacuum chamber where all stages are individually pumped, thereby gradually lowering the pressure remaining on subsequent stage. The stinger rod and the electrode are moved by means of a chain or a cable and are controlled by a power drive and a gear box, depending on signals from the electric arc. A special clamping head provides the electrical and mechanical linkage between the electrode and the stinger rod, or more exactly, between stinger rod and stub, made out of the metal to be melted, which is welded onto the electrode. The design of this clamping head is of paramount importance, as current ratings as high as 20,000 to 40,000 amps must be delt with.

The electrode hangs in the vacuum chamber and reaches the bottom of the water-cooled crucible. The furnace chamber is connected to the pumps and vacuum valves by a specially designed dust separator. On loading the furnace, the crucible unit with its water jacket is flanged underneath the furnace chamber with special vacuum seals. The bus bars are connected to the stinger rod and the crucible. The stinger rod is electrically isolated from the crucible and normally forms the negative potential. The crucible unit with its water jacket is brought into position by means of a trolley provided with a hydraulic ram.

In case of the crucible burning through, water may penetrate into the furnace and thereby create an overpressure. Modern furnaces are, therefore, provided with a pressure release valve which is ducted to the open atmosphere, thereby avoiding

the concentration of hydrogen in the furnace building.

It has been found that the operation of vacuum arc furnaces involves some inherent risks, particularly in the case of melting titanium and zirconium, which are highly reactive and may dissociate water when hot. It is, therefore, essential to design production vacuum arc furnaces for remote control and to errect these furnaces in reinforced concrete cubicles or in an armor plate housing. Although the vacuum arc may be remotely controlled by electric-signals, it is highly desirable that furnace operators watch the melting progress and see the electrode and the melting pool. The color and shape of the arc are significant for the proper working conditions and, therefore, an excellent guide for adjusting the automatic controls. Also, side arcs must be visually watched.

W. C. Heraeus provides its arc furnaces with tele-optic observation systems, which might have prevented some recent mishaps. Television cameras for observing the melting process, which must allow for colored images, have not given satisfaction. The electrical screening of the wide-spectrum HF interferences of the arc is too difficult.

Loading and unloading

The electrode is placed in the crucible while outside of the cubicle, and the crucible and the electrode are brought into the cubicle and placed underneath the furnace. The electrode is clamped onto the stinger rod and subsequently retracted into the furnace body, while the crucible is flanged onto the furnace body by means of the vacuum seal. The furnace is then ready for operation.

Upon completion of the melt, or after cooling the ingot, air is admitted into the furnace. The crucible is lowered and shifted outside the cubicle by means of the trolley. By tilting the crucible, or in the case of a flanged bottom crucible by undoing the bottom flange, the ingot is retracted from the crucible. For ingots of large diameters, say over 8 in., shrinkage of the ingot is such that the unloading of the crucible never causes any trouble.

Advantages of the stinger rod

The chain suspended stinger rod, which is led into the furnace through a vacuum seal, seems to be the most attractive method of electrode control. Electrodes of any reasonable length, cross section, and weight may be melted without calling for adaptations of the furnace. Current is supplied to the stinger rod outside the furnace by means of flexible cables, so there are no sliding contacts or rollers. Inside the furnace there are no complicated or delicate components. The stinger rod and dynamic seal are shown in Fig. 2.

The use of the flexible chain drive instead of a rack or rigid drive does away with all risks of damaging vital parts when running down the electrode to the crucible bottom. Furthermore, the elasticity of a chain drive allows for pulling of ingots which might have slightly fused onto the crucible bottom during the welding of primary ingots. The wide spacing of the stinger rod guides in the dynamic seal and the rigidity of the sealing chamber provide for accurate line-up of the electrode, and no further supports or centering gear is required. The apparent handicap of the stinger rod is the sliding vacuum seal, but a multi-station dynamic seal with individually pumped stations gives a very reliable vacuum seal. As the current is supplied to the top end of the feeder rod, automatic compensation of the voltage drop along the electrode is essential.

Arc control

There are several reasons why automatic control of the arc length cannot be based on the arc voltage

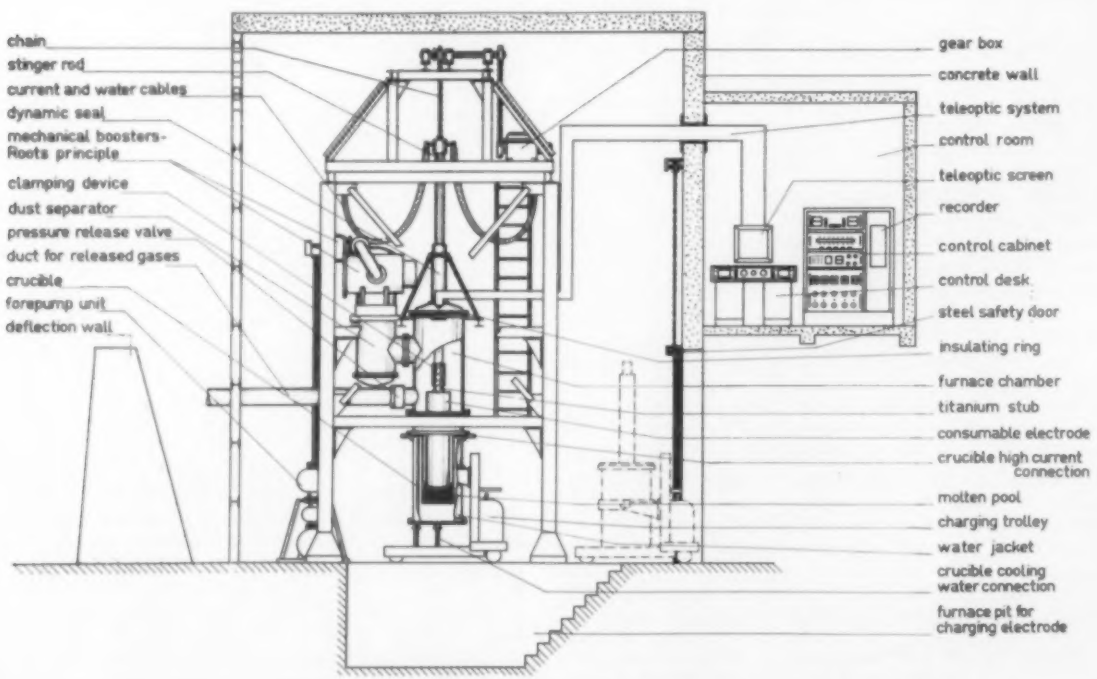


Fig. 1—Schematic diagram of a production consumable electrode vacuum arc furnace (Heraeus design).

alone. For most vacuum arc furnaces, the electrode length varies during the melting cycle. This results in a continuous decrease of the voltage drop across the electrode length. Also, most electrodes heat up during the melting cycle, which leads to an increased specific resistance and therefore to an increase in voltage drop across the electrode. With compacted sponge or powder electrodes, sintering occurs during heating up and prior to the melting. This leads to a decrease in specific resistance and consequently in to a decrease voltage drop.

These facts would be of minor importance could the voltage drop across the arc be measured. But this is difficult due to the fact that the voltage gradient of an arc—the ratio of the variations of the arc voltage to the variations of the arc length—under vacuum is very small. Johnson et al.[9] quote a voltage drop of approximately 1 v per in. in vacuo in comparison to 26 v per in. under 0.8 in. avg. length and 7.6 v per in. for longer arcs under higher pressures. This small voltage gradient is further complicated by a fluctuating voltage drop of the electrode and makes safe control of the arc length difficult.

For safe operation, the gap between the electrode and the melting pool must be kept shorter than the distance between the electrode and the crucible. Also, the ingot surface deteriorates with increasing arc length, particularly if there is large variation in arc length. To overcome these difficulties and to comply with the requirements of modern melting techniques the *Heratron* control was developed. With this device, the rate of feed is no longer controlled only by arc voltage, but also by other electrical signals. All signals are electronically amplified and passed on to the two motors of a differential gear. A minor modification in motor rpm influences the rate of feed and if need be, reverses electrode motion.

Such an electronic control, together with the differential gear, results in effective response times of the order of 10 to 20 milliseconds. This system has low inertia, as there are no motors to be reversed, and appears to be superior to other vacuum arc control systems. It allows for positive control of arc length between ½ and ¾ in.

Vacuum considerations

It has become evident that the arc under dynamic vacuum is far superior to the previously used inert gas arc under reduced pressure. Its main advantages[10,11,12] are: better degassing of metal, better arc stability, reduced risk of formation of parasite arcs, reduced probability of crucible burn-through (as vacuum arcs are never focused to the same degree as arcs under higher pressures), and higher melting speed.

Present experience leads to the conclusion that a pressure of 10^{-5} mm Hg measured in the furnace chamber is advisable. A further decrease of the prevailing pressure in a furnace chamber makes only little sense, as the flow impedence of the free cross section between electrode and crucible would not allow for lower pressures around the arc zone, taking into consideration the normal rate of gas evolution during arc melting. It has been proved that pressures lower than 10 to 100 μ are not obtainable in the surroundings of the actual arc zone.[13]

Problems involved

Many vacuum arc furnaces for titanium and zirconium melting operate under dynamic vacuum of 100 to 1000 μ. There are results which positively

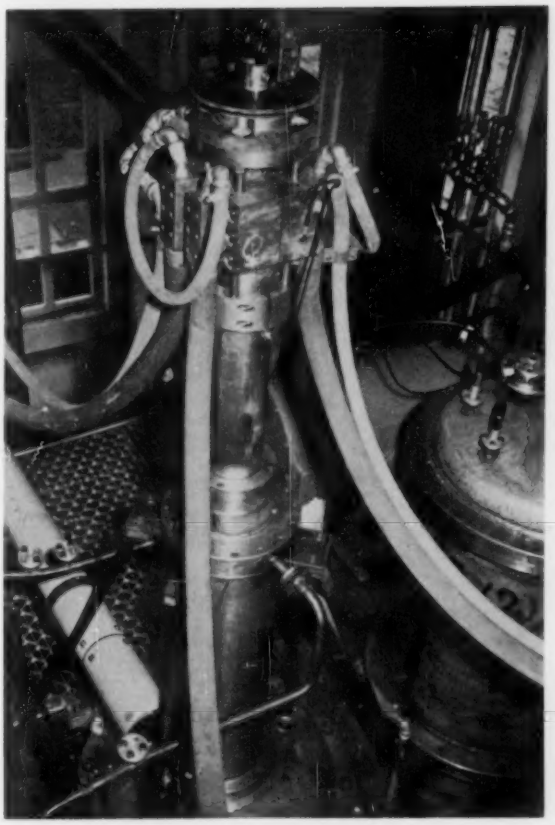
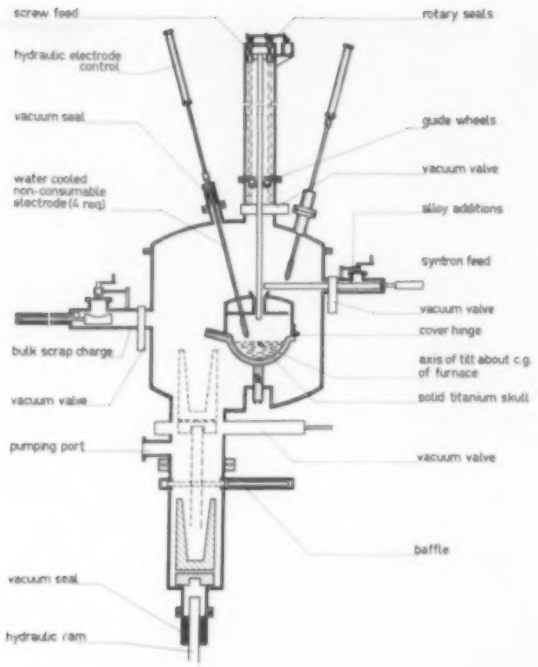


Fig. 2—Stinger rod with the dynamic vacuum seal.

prove that pressures of 10 to 100 μ lead to an even lower gas content than is obtainable with metals melted in the higher pressure range. The main objection, however, against melting under a pressure of 100 to 1000 μ is that these higher pressures are very close to the glow discharge range. Under certain conditions these pressures fall quite clearly within this critical range, which extends from approximately 500 μ to 5 mm Hg. Altogether it is a very dangerous pressure range, as the arc might be converted into a glow discharge of high current rating which stops the melting and favors the formation of parasite arcs between crucible wall and electrode. There is some doubt whether, physically speaking, it is still a matter of a glow discharge, and Johnson[14] classifies this phenomenon as a *displaced arc*. Such displaced arcs were most likely the cause of some furnace explosions. In this connection it is quite significant that up to now no furnace working under a pressure of 10 μ has exploded.

Vacuum pumps

The required suction speed of the pump is quite easily determined. In a test, the maximum gas volume which might occur is measured during melting. It goes without saying that this mass of gas depends on the melting speed and the specific gas content of the metal. The pumping speed is then selected so that the maximum gas evolution may be pumped off at a pressure of 10 μ. It is of minor importance if pressures slightly higher than 10 μ must be tolerated in case of highly gaseous metals, as pumps of the required speed would not be available or feasible. It



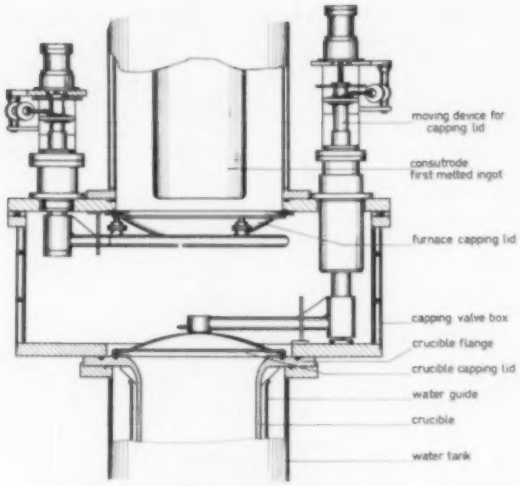


Fig. 4 Above: Schematic diagram of a capping device for vacuum arc furnaces, which allows for removal of crucible without waiting for the ingot to cool.

Fig. 3 Left: Schematic diagram of a large skull type furnace, designed by J. L. Ham (courtesy National Research Corp.).

is a well known fact that the degassing is heavier in the early stages of a melt and decreases towards the end of a melt.

Two types of pumps have proven extremely successful on vacuum arc furnaces. First is the mechanical booster pump (Roots principle), having its maximum speed in the 10 to 100 μ range, which is exactly the range that applies to vacuum arc melting. Furthermore, this pump provides a very high speed in the low millimeter range. A quick pump down of the vacuum arc furnace is one of the main features of this pump, thus considerably increasing the overall productivity of the plant.

Violent gas evolutions and pressure rises are quickly and easily dealt with. The capability of Roots pumps to handle water vapors and hydrogen which develop in case of a water penetration is excellent, thus considerably reducing the risk of explosion.

Another very suitable pump is the oil diffusion ejector pump, such as the KS series of the Consolidated Electrodynamics Corp. These pumps have a maximum of suction speed in the 10 μ range. Another all-important feature is their double speed for hydrogen, one of the predominating gases in vacuum furnaces.

It has been found that a parallel operation of both pumps is ideal for arc furnaces, the combined pumping set having the features of both systems. Pumping speed curves are shown in Fig. 6.

Safety considerations

It is a regrettable fact that vacuum arc melting has led to some 10 explosions, some of which have been fatal. Although most of the reasons for these explosions have been eliminated by improvement of arc controls and the control gear in general, there are still some inherent risks.

Liquid metal at a temperature of 1600°C or higher in a water-cooled copper crucible, and a power concentration of 500 kw and more, in the comparatively small area of the arc, may be dangerous if the crucible burns through and penetration of water occurs, forming hydrogen.[10] To prevent such accidents it is recommended: a) keeping the arc length extremely short, by all means shorter than the lateral gap between electrode and crucible wall, b) melting under vacuum, i.e., at pressures in the arc zone below the critical glow discharge range. In the furnace tank a pressure of approx 10^{-2} mm Hg must prevail in order to take into account the pressure gradient along the crucible. As previously stated, and to the best of our knowledge, all arc furnace explosions up to now have occurred with furnaces of working pressures higher than 10^{-1} mm Hg.

c) The furnace ought to be provided with a pressure release valve ducted to the atmosphere outside the building, to carry hydrogen which might form, to the open atmosphere. This valve, however, must shut automatically and vacuum tight after releasing an over-pressure to prevent oxygen of the atmosphere from penetrating into the furnace.

d) In case of a water penetration, the furnace pressure should be kept as low as possible. This calls for high speed mechanical pumps. Mechanical boosters (Roots pumps) of a speed of 4000 cfm have proved very successful and they have always been capable of dealing with water penetrations, thereby keeping the pressure in the low range. As even stoichiometric oxyhydrogen gas mixtures at a pressure of up to 40 mm Hg will never damage a vacuum chamber of normal construction should they ignite, such a pump is an excellent precaution against hydrogen explosions.

e) In spite of all technical precautions one cannot positively exclude the risks of explosions, and it is therefore advisable to place the vacuum arc furnaces in explosion-proof reinforced concrete cubicles.

As for steel, there is little knowledge on the kinetics of reaction in vacuum arc furnaces, and it cannot be said whether hydrogen might develop in case of a water penetration during a steel melt. The fact that, after some thousands of steel melts, there has been no explosion is certainly no conclusive proof that there is no danger.

Outlook for further development

Skull melting and pouring: There are some definite disadvantages to conventional consumable-electrode practice. The preparation of electrode is, as a rule, quite expensive and, in some cases, not even feasible. The conventional electrode melting technique excludes alloy balancing during the melting cycle, a measure that would call for a prior sampling. Thirdly, although the cold mold melting leads to a more favorable solidifying of ingots for pure metals and results in superior ingot qualities, it is quite often desirable to have means of pouring, be it to get more homogeneous alloys or be it for shape casting.

For titanium and zirconium, the primary melt may be interrupted at intervals, and by means of suitable feeder units scrap may be brought into the crucible. This procedure is rather expensive, but at the present prices of titanium it is still commercial.

A better proposition is skull melting. All cold mold, vacuum arc furnaces are basically skull melting furnaces, as liquid metal is always forming a skull in the cold mold. The liquid pool is, thereby, separated from the cold crucible walls. This is not necessarily welcome with all cold mold furnaces, but for the specific skull-melting furnaces it is a fundamental component, as not all skull-melting furnaces are provided with water-cooled crucibles. Such furnaces have been one of the topics in research and development work for the past few years.[16] Skull-melting furnaces may handle scrap of any shape and dimension and provide for subsequent casting of ingots or shape castings. Casting from cold molds is practical, provided sufficient amperage is available, as some 80 pct of a charge may be kept liquid. Fig. 3 shows a large skull furnace.

Means to increase production of vacuum arc furnaces: The main aim of vacuum arc furnace designers is to increase output and to simplify design. Theoretical maximum melting capacity is imposed by amperage. A given amperage can melt only a maximum quantity of metal—which for titanium is 1.1 lb per min per 1000 amps. To realize even this, a *continuous*, vacuum, arc furnace must be designed, which involves delicate but not insurmountable problems. For titanium, a continuous compacting of sponge electrodes or a continuous welding of electrodes through appropriate vacuum locks or dynamic seals might be suggested. Again for titanium, the primary melt might be immediately followed by a secondary melt and after this secondary melt the ingot must be extracted from the furnace through appropriate locks or dynamic seals.[17] Such a furnace would certainly mean an enormous effort on the equipment side, and—as far as it can be judged—at least double the capital expenditure.

Consumable-electrode vacuum arc furnaces have a utilization of roughly 40 pct, the remaining 60 pct going for loading and unloading the furnace, for pumping and, as a major item, for cooling off the ingots. This rather unfavorable relation may be improved greatly by unloading the furnace immediately after a melt, without cooling the ingot in the furnace. In order to exclude the reaction between the hot ingot and the atmosphere, a suitable capping device must seal the crucible off. Such a capping gear is actually on test at the Hanau works of the Heraeus Co. Fig. 4 gives a schematic diagram of this capping device.

The remaining 20 pct of down-time may also be reduced by providing automatic handling equipment. Every effort taken on these grounds will pay off, as labor cost accounts for a very considerable proportion of the melting cost.

Selection of method

Examination of Fig. 5 shows clearly that for the best properties there are only two methods, melting in a vacuum induction furnace or vacuum arc melting. A combination of both techniques leads to top quality.

Many companies are at present confronted with the decision on what technique to adopt. It has always been found that practical tests are the best guidance for selection. It follows from Fig. 5 that there is little difference in the results of these two

		Melting Variables			Product Characteristics				
		Temperature	Pressure	Time Metal Molten	Hot Workability	Gas Content (ppm)	Cleanliness	Segregation	Physical Properties
Air Melting		2500° F to 3100° F	1 atm.	2 hours to 3 hours	poor to fair	H_2 4–20 O_2 10–150 N_2 30–500	fair	normal	normal
Vacuum Degassing		2500° F to 3100° F	melting: 1 atm. degassing: 0.5–10 mm	1/2 hour to 4 hours (for 40 to 150 tons steel)	fair to good	H_2 1–4 O_2 10–60 N_2 40–120	fair to clean	normal	improved by 5–50 per cent
Vacuum Induction Melting		2500° F to 3100° F	1 to 100 microns	1 hour to 5 hours	good	H_2 <1 O_2 4–10 N_2 3–50	very clean	normal	improved by 20–200 per cent
Vacuum Arc Remelting	from air melted electrode	2500° F to 8500° F	5 to 500 microns	15 minutes to 30 minutes	good	H_2 1–2 O_2 6–30 N_2 40–100	clean	relatively free	improved by 10–100 per cent
	from vacuum induction melted electrode				very good	H_2 <1 O_2 1–5 N_2 2–20	extremely clean		improved by 30–300 per cent

Fig. 5—Comparison of different methods of vacuum melting and degassing (after A. M. Askoy, Vacuum Metals Corp.).

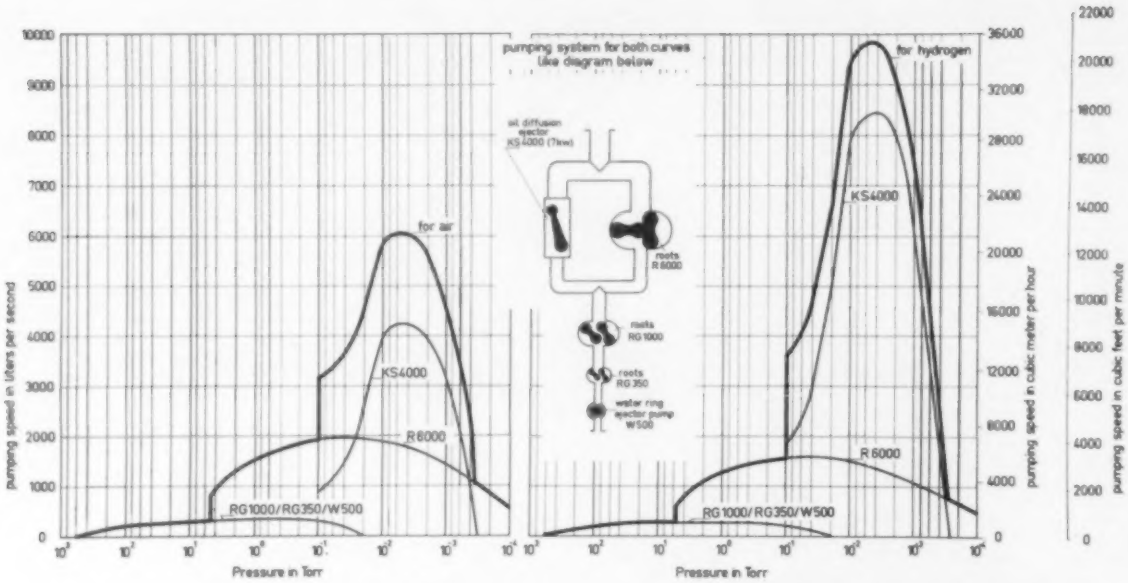


Fig. 6—Pumping speed curve of a consumable-electrode vacuum arc furnace pumping system for air and hydrogen.

techniques. The ultimate gas figure and the improvement in physical and mechanical properties are quite comparable; operational reasons will, therefore, have a decisive influence. In vacuum induction melting all constituants may be loaded into the crucible in any shape, and a premelting under atmosphere is unnecessary. On the other hand, for consumable electrode vacuum arc melting the electrode must be made up by conventional melting and casting techniques in atmosphere. Alloying is feasible on a vacuum induction furnace. On consumable-electrode furnaces it is more difficult and calls for a special feeder gear. But once the melt is over, no alloy balancing can be done. It is, therefore, impossible to take a sample for analysis prior to the alloying operation except in case of skull melting.

On the other hand, consumable-electrode arc melting is considerably cheaper, and melting costs are only some 25 pct of those for vacuum induction melting. There is no limitation with regard to the ingot weight, and the consumable-electrode technique will always be chosen when it is a matter of multiple remelting under vacuum or when there are crucible contaminations.

Results

Vacuum melting leads to lower gas content, particularly, as far as oxygen, nitrogen, and hydrogen are concerned, and cleaner melts are obtained. There is an almost complete lack of center porosity and segregation; there is a more positive alloy control, as no alloy constituants are transformed into slag. The only critical problem is metals of high vapor pressure.

Physical properties are greatly improved as far as workability is concerned. Better elongation and impact strength, as well as an improvement in stress rupture properties, are obtained. On the other hand, there is little change in yield strength and tensile strength. On ferromagnetic alloys there is an important improvement in magnetic properties, such as coercive force and magnetic permeability. Stainless steels show a much better corrosion resistance, particularly along welding seams, as vacuum melting leads to extraordinarily low carbon figures. Carbide formations are no longer noticed. Furthermore, there is an important reduction in anisotropic structure. Details, particularly with regard to enhanced workability, may be found in the literature. The most significant results have been found on super alloys which contain titanium, aluminium, and molybdenum as hardening agents. For these superalloys, ball-bearing steels, and stainless steels the extra melting cost is normally justified.

Summary

The field of applications for the consumable-electrode vacuum arc melting process is immensely wide. The physical and chemical reactions should be further investigated to exploit the full benefit of the possibilities given by these techniques. Up to now, most users have been rather reluctant to publish results. It would, however, be for the mutual profit of all users, if an extensive exchange of information could be arranged.

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AIME METALLURGICAL SOCIETY OF AIME NEWS

Winner Of Student Prize-Paper Contest

William J. Babyak of McKeesport, Pa., is the Undergraduate Division winner of the 1957 Student Prize-Paper Award Contest for student members of the Metallurgical Society of AIME. An abstract of his winning paper, *The Relation Among the Grain Boundary Area, Twin Boundary Area and Hardness of Recrystallized Cartridge Brass*, follows:

Abstracts

A simple linear intercept counting method, involving no assumptions as to the shape and distribution of grain boundaries, is used to study the effect of grain size on the hardness of recrystallized cartridge brass. It is shown that a linear relation exists between the Brinell hardness and the sum of the grain and twin boundary areas.

Comparison of the twin and grain boundary areas reveals the existence of a nearly parabolic law, from which it is shown that a finite amount of grain boundary must be present before the development of any twins. It is observed that there seems to be a regular variation of the relative amount of twin to grain boundary, the ratio being larger, and even exceeding one, in the coarse-grained brass.

William J. Babyak was born in McKeesport, Pa., in 1932 and graduated from McKeesport High School in 1950. He was employed as a laboratory technician in the metallurgy section of Westinghouse Atomic Power Div., Bettis Site, from 1952 to 1955 and concurrently studied engineering at Carnegie Evening School in Pittsburgh.

He was granted an educational leave of absence from Westinghouse in 1955 to attend full-time classes at Carnegie and returned to Westinghouse during the summers of 1956 to 1957. Babyak received his B.S. in

W. J. BABYAK

metallurgical engineering from Carnegie Institute of Technology in 1957.

During undergraduate work, he was aided by scholarships from Westinghouse, Carnegie Tech, and Standard Oil of California. Babyak is currently attending the graduate school at Carnegie Institute of Technology studying metallurgical engineering and working part-time as a teaching assistant in the undergraduate physical metallurgy laboratory.

A student associate member of AIME and ASM, he was presented the *Lewis E. Young Award* by the Western Pennsylvania Section of the Women's Auxiliary to the AIME at Pittsburgh in 1956.

Nuclear Congress To Be Held In March

The 1958 Nuclear Congress will be held at the International Amphitheatre, Chicago, from March 17 to March 21, 1958. This Congress, sponsored by the American Nuclear Society and over thirty national engineering and the scientific societies, is the fourth of such meetings. It is under the coordination of the Engineer's Joint Council.

The thirty-seven sessions will cover: commercial use of radioactive tracers, reactor component development, fabrication, and testing, standardization, codes, and licensing, reactors for process heat and radiation, production and miscellaneous application of radioisotopes, reactor operation and maintenance, fuel, control, moderator and coolant materials, experimental power reactors and advanced concepts, health physics and instrumentation, reactor physics, temperature measurements and high temperature instrumentation, waste treatment and disposal, reactor plant instrumentation, reactor location and safety, thermal and mechanical design, reactor control instrumentation, progress in commercial power reactor development, reactor plant materials, nuclear education and training, fuel element development, fabrication and testing, reactor systems analysis, reactor safety and startup instrumentation, research and test reactors and critical assemblies, chemical reprocessing; water contamination and treatment; and reactor shielding and containment.

Preprints of the papers may be ordered from the *American Institute of Chemcial Engineers, 25 West 45 Street, New York 36, N. Y.* Price: 50¢ each. Publication of the transactions of the Nuclear Engineering & Science Congress in one volume is not planned.

EJC and SMC 1958 Programs Listed

A recent EJC report listed the 1958 program for the Engineering Manpower and Scientific Manpower Commissions. The activities of EMC and SMC will have the following goals:

1) To achieve and maintain public attitudes on careers (including teaching) in the engineering and scientific professions based on positive, realistic, and properly organized ideas of their requirements, rewards, and growing importance. The primary task here, through public relations, is to preserve realistic attitudes about future careers in the technical fields of demand.

2) To develop and define programs of engineering and scientific man-

(*Continued on page 201*)

AIME Awards and Honors Presented at Annual Banquet

Part of the program at the AIME Annual Banquet held at the Waldorf-Astoria Hotel in New York on Wednesday, February 19, during the Annual Meeting, was the presentation of AIME awards and honors to a distinguished roster of recipients.

The awards and their winners were: James Douglas Gold Medal to J. R. Gordon; William Lawrence Saunders Gold Medal to William J. Coulter; Charles F. Rand Gold Medal to John F. Thompson; and Anthony F. Lucas Gold Medal to Carl E. Reistle, Jr. Also presented at the Banquet, to John R. Suman, was the John Fritz Medal, a joint award sponsored by the four Founder Societies—ASCE, AIME, ASME, and AIEE.

J. R. GORDON
James Douglas
Gold Medal, 1958

W. J. COULTER
William L. Saunders
Gold Medal, 1958

J. Roy Gordon, executive vice president of The International Nickel Co. of Canada Ltd. and its subsidiary, The International Nickel Co., Inc., is a native of Kingston, Ont., Canada, and a graduate of Queen's University with a B.Sc. in chemistry. Soon after graduation, he joined M. J. O'Brien Ltd. as research metallurgist, leaving to join the Ontario Research Foundation, Toronto, where he eventually became Assistant director of metallurgy. In 1936 Mr. Gordon became associated with International Nickel as director of the newly established Research Dept. at Copper Cliff, Ont. He became, successively, assistant to the vice president of the Canadian company; technical assistant to the vice president; assistant vice president; assistant general manager of Canadian operations; vice president, general manager, and director of Canadian Inco in 1953; director of the U. S. company in 1954; and in 1955 he became vice president of The International Nickel Co. Inc. He was elected to his present posts in 1957. Mr. Gordon is also a member of the executive committee of the parent company. He is a director or officer of a number of other concerns, among which are Whitehead Metal Products Co. of Canada Ltd., Canada Life Assurance Co., and The Toronto-Dominion Bank. A recipient in 1948 of the CIM medal, he is a former president and director of the Ontario Mining Assn., member of the Board of Governors, Ontario Research Foundation, and a former member of the Royal Ontario Mining Commission.

William Jesse Coulter, a native of Murray, Idaho, is retired vice president of Western Operations for Climax Molybdenum Co., now American Metal Climax Inc. A graduate of the State College of Washington with a B.S. in mining, an E.M. degree, and an honorary doctor of laws, he also holds the professional degree of mining engineer from Montana School of Mines. For 12 years after college, he worked for the Granby Consolidated Mining, Smelting, and Power Co. in Alaska and British Columbia. He left that company to become mine superintendent with the American Metal Co. at Terrerro, N. M., later going to Climax, Colo., as general superintendent of the mining and milling operations of Climax Molybdenum. Transferred to Denver in 1935 as general manager of Western Operations, he was elected vice president in 1949, the post he held until his retirement in 1953. Mr. Coulter, who makes his home in Denver, was a Director of AIME from 1949 to 1951. The author of numerous papers on mining and milling practices at Climax, he was chairman in 1949 of the mining methods committee which prepared material for a book published in 1945, Transactions, Vol. 163, on Mining Practice.

J. F. THOMPSON
Charles F. Rand
Gold Medal, 1958

C. E. REISTLE, JR.
Anthony F. Lucas
Gold Medal, 1958

John F. Thompson, chairman of the board of The International Nickel Co. Inc. and The International Nickel Co. of Canada Ltd., was born in Portland, Me., and received B.S. and Ph.D. degrees from the School of Mines, Columbia University. He joined Inco of Canada in 1906 as a metallurgist to design and operate the company's first research laboratory at the Oxford Works, and, in the period 1906 to 1918, established and headed the first Technical Dept., predecessor of Inco's Development and Research Div. Manager of Operations in 1921, Dr. Thompson supervised the construction and initial operations of the Huntington Works. His successive positions at Inco have been assistant to the president, director, vice president, executive vice president, president, and chairman of the board. In 1952 he relinquished the presidency of Inco of Canada, retaining his post as chairman of the board. He is also chairman of the U. S. subsidiary, The International Nickel Co. Inc. Dr. Thompson, director of many other organizations and recipient of numerous awards, was honored by Inco in 1956 when a new town and nickel mine in northern Manitoba were named for him.

Carl E. Reistle, Jr. is AIME Past President and executive vice president of Humble Oil and Refining Co. Born in Denver, he received a B.S. in chemical engineering from the University of Oklahoma, spending his vacations as a roustabout for the Carter Oil Co. Putting his education and vacation experience to use, he joined the USBM in Bartlesville, Okla., as a junior petroleum chemist. During his years with the Bureau, he visited and worked in many major oil fields and published a number of articles on oil field brines, paraffin problems in the production of crude oil, and operation of flowing wells. He became chairman of the East Texas Engineering Assn. in 1933, after leaving the USBM. Mr. Reistle's work as Association chairman led to a job with Humble Oil, first as engineer in charge of the Petroleum Engineering Div., and later as chief petroleum engineer, general superintendent of the Production Dept., and manager of production operations. In 1948 Mr. Reistle was elected to the Humble board of directors and in 1955 became vice president, before assuming his present post in 1957. Active in many professional and civic organizations, he was technical advisor for District III, Petroleum Administration for War, and national vice chairman of the Oil Industry Advisory Committee of OPA, during World War II. Mr. Reistle was AIME President in 1956.

J. R. SUMAN
John Fritz
Medal, 1958

John Robert Suman, AIME member in the Society of Petroleum Engineers, is often called the "father of petroleum engineering." Born in Daleville, Ind., he attended the University of Southern California and the Mining College, University of California, graduating with a B.S. in

mining engineering. Soon after graduation, Mr. Suman joined the Rio Bravo Oil Co. in Houston, as assistant geologist and then chief engineer. After a short time with another company, he rejoined Rio Bravo in 1919 as assistant to the vice president and general manager. In 1921 he was promoted to vice president and general manager. Before going to Humble Oil & Refining Co. as director in charge of production, he served in executive positions with two other oil concerns. In 1933 he was elected a vice president and director of Humble Oil. Mr. Suman became a vice president and director of Standard Oil Co. (New Jersey) in 1945. He retired to open a consulting office in Houston in 1955. President of AIME in 1941, Mr. Suman was awarded the Anthony F. Lucas Gold Medal in 1943 and became an Honorary AIME Member in 1946. Mr. Suman is a member of the advisory committee of the board of directors of Chemical Corn Exchange Bank; director of Schlumberger Well Surveying Corp.; honorary director of the American Petroleum Inst.; and a member of the American Assn. of Petroleum Geologists, Mid-Continent Oil & Gas Assn., and Independent Petroleum Assn. of America. Author of *Petroleum Production Methods* (a standard reference book in the field), he was awarded an honorary doctor of engineering degree by the South Dakota School of Mines in 1941.

EJC and SMC Programs

(*Continued from page 199*)

power allocation, organization, and utilization for use in military, industrial, and other manpower programs to insure optimum professional use of this vital resource in the national health, safety, and interest. Specifics here will involve, during 1958, not only a watchdog function in the administration of military manpower programs now in effect, but further constructive changes to help meet the additional manpower requirements of expanded defense programming in technology.

3) To provide a clearinghouse of information and a channel of communications between the profession, industry, government, and the general public on engineering and scientific manpower. This involves the development and assembly of information on engineering and scientific manpower and the critical synthesis of such information into a consistent and authoritative whole, available to industry, education, government, and the general public. This includes also the conduct of surveys of demand for technical manpower and related matters essential as guides to realistic educational and utilization policies.

4) To maintain active liaison with the many Government agencies having interest and responsibilities in problems effecting the education and utilization of engineering and scientific manpower, to insure registration of the appropriate viewpoints of the engineering and scientific professions. This includes constant contact, informal and through advisory committee memberships, with the Office of Defense Mobilization, the President's Committee on Scientists and Engineers, The Dept. of Defense, the Selective Service System, the National Science Foundation, and other executive agencies. It includes also response to Congressional requests for information on various legislative aspects of the education and utilization of engineering and scientific manpower.

5) To assist in the task of promoting public interest and action in educational problems affecting the development of engineering and scientific personnel. This is largely a task of highlighting appropriate problems of secondary and higher education through public relations activities and, in the secondary school area, of promoting more active liaison between engineers and scientists and school officials.

The following regular services of EMC and SMC will be continued in 1958: Monthly publication of the EMC-SMC Manpower Newsletter; the annual exhibits of engineering and scientific career literature at the meeting of the National Science Teachers Assn.; the support of the guidance activities of ECPD; guidance and help on individual and company military service problems; serving and/or routing of requests for information on problems of technical manpower; meetings and conferences with public information media representing interests in technical manpower matters; the participation of EMC and SMC personnel, as requested, in appropriate conferences, meetings, etc.; and the Annual Survey of Demand for Engineering Graduates.

Belgium to Hold Iron and Steel Conference

Liege, Belgium will be the opening site of the two week 1958 International Conference on the Metallurgy of Iron and Steel, beginning Wednesday, June 18 to Saturday, June 28, 1958. The Conference will climax the windup of the First International Congress on Vacuum Techniques scheduled to end a week before in Namur, Belgium.

The first week's sessions, held in Liege, will cover new methods for the production of steel. The topics discussed will be: bottom blowing of the converter; top blowing of the converter; steel production in the open hearth furnace; and large arc furnaces.

Luxembourg will be the first scene of the second week's sessions which will cover new methods for the reduction of cast iron. The subjects discussed will be: low shaft furnaces; new methods of direct reduction; preparation of the materials for the blast furnace; and special blast furnace techniques.

The remainder of the second week's session will be held in Charleroi, with continuous casting of steel as the theme. Discussions will cover: the continuous casting of steel—theory and experimental equipment; and the industrial application of continuous casting of steel and actual installations. The sessions will close in Brussels.

The First International Congress on Vacuum Techniques which precedes the Iron and Steel Conference, will be held in Namur, Belgium from June 10 to 13. This congress is officially sponsored by the Commissariat General of the Belgium Government with the Brussels 1958 International and Universal Exhibition.

Germany Holds Iron and Steel Congress

The annual congress of the Verein Deutscher Eisenhuettenleute was held at Duesseldorf on October 25 and 25, 1957. The two day meeting of the Association, which is dedicated to the engineering and scientific side of steel making, took the form of a series of technical lectures climaxed by the major address by the Association president, Dr. Hermann Schenck, faculty member of the Institute of Iron and Steel Mill Science of the Technische Hochschule, Aachen, Germany. He spoke on the economic aspects of expansion and rationalization in the West German steel industry.

Dr. Schenck's paper discussed the problem of maintaining price stability in the face of rising production costs. He saw stable West German steel prices as essential prerequisites to the maintenance of stable prices in general (i.e. as a bulwark against inflation) and to the maintenance of West Germany's preeminent position in the export steel market. Dr. Schenck also cited that West German domestic steel prices are lower in general than those prevailing elsewhere, even in England and the United States, except where the latter employ ultra-modern processes of a fully continuous nature.

Some of the other papers discussed at the annual congress covered the basic hot-blast cupola furnace in an integrated steel mill, the mechanical removal of scale from wire by blasting, physical properties of coke and their effects on blast furnaces, mathematic statistical evaluation of blast furnace performance, and reduction of coke consumption and increase of pig iron production through ore preparation.

EJC Committee Report on Air Pollution

The Engineers' Joint Council Air Pollution Committee has developed the following policy principles for consideration by those concerned with air pollution and its control:

1. The common goal is to maintain a reasonable degree of purity of our air consistent with: a) the public health and welfare and public enjoyment thereof, b) the continued industrial development of our country, c) the protection of plant and animal life, and d) the protection of physical property and other resources.

2. Air pollution means the presence of one or more contaminants, such as dust, fumes, gas, mist, odor, smoke, or vapor, in quantities, of characteristics, and of duration such as to be injurious to human, plant or animal life or to property, or which unreasonably interfere with the comfortable enjoyment of life and property.

3. In the development of criteria for the control of air pollution, it must be recognized that although the atmosphere is a medium suitable for the disposal of waste products, true conservation requires that the public interest be protected against excessive and unsafe use of the atmosphere for this purpose.

4. Effective criteria are required to serve two purposes, namely, enforcement and protection of the public interest. The first of these can be most effectively accomplished at the points of emission, the second at the points of use. Sound criteria must give relative evaluation of these two measures.

5. In the development of standards, plans, rules or regulations, due consideration must be given to local conditions, such as topography, meteorology, industrial development, and area planning.

6. Emphasis should be placed on education and voluntary cooperation by all persons and organizations who may contribute to air pollution or who are interested in its control. Encouragement should be given to groups or associations of municipalities, industries, or other groups, who severally or jointly can be of help in planning its effective abatement.

7. Laws with appropriate penalties may be necessary, but their use should be reserved for cases where cooperation and voluntary action do not prevail.

8. During an emergency, such as may develop under adverse meteorological conditions, short-time curtailment of community and industrial activities which contribute to pollution may be necessary. Although such an emergency condition is seldom encountered, it is essential that duly constituted governmental authority anticipate such a problem, and be prepared to act through a prearranged procedure.

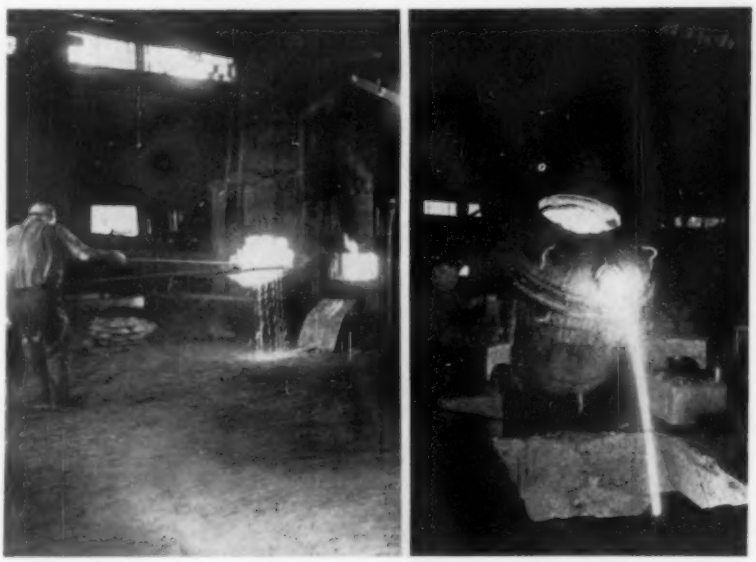
9. The objective of air pollution legislation is to recognize the right to the use of the air and the responsibility to avoid its abuse. It is the duty of the engineer to contribute to the knowledge of his profession in the preparation of legislation that will accomplish this objective.

10. Air pollution and its control involve many scientific problems that have not yet been solved. There is no simple or quick answer. Continued research in this field is vitally necessary. The engineering profession has the obligation of reaching the best engineering solutions to these problems.

11. It is the responsibility of the engineering profession to participate vigorously in the field of air pollution control.

Copies of the report, which also lists causes of pollution and methods of control, are available from Engineers Joint Council, 29 West 39th Street, New York 18, N. Y., for five cents per copy. Please specify report No. 107.

Only Two Companies Still Handle Puddle Wrought Iron in U. S.



Pictures above show the hand puddling process being used by Lockhart (left) and the Byers process (right) at the point where the purified iron is poured into the molten silicate. Under the Byers process, pig iron is melted and purified, then poured into a molten mass of iron silicate. The difference in temperature between the two substances results in thousands of explosions which shatter the molten metal into small fragments and produce a "sponge" or iron impregnated with silicate which gives it a high degree of resistance to corrosion.

T. J. Gillespie, Jr., (left) president of Lockhart Iron and Steel Co., McKees Rocks, Pa., inspects one of the last hand puddled "sponges" of wrought iron, which was recently produced at Lockhart's plant. Also witnessing the ceremony is Buckley M. Byers, president of A. M. Byers Co., Pittsburgh. Byers still manufactures substantial quantities of wrought iron by a modern mechanical process.

Translation Service Now Available

A Cooperative Translation Service was started about 10 months ago by The Iron and Steel Institute, in cooperation with a number of English firms in the steel industry. The service produces translations at the rate of about one a day, and issues lists of translations available every two weeks.

Inquiries as to the translations now available should be directed to *The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England.*

Atom Fair in March

Spotlights will be on American industry's newest developments in the atomic field at the 1958 Atom Fair, to be held March 17 to 21, at Chicago's International Amphitheatre. The Atom Fair, sponsored by Atomic Industrial Forum, will display a wide cross-section of products and services available from firms in the atomic industry.

Concurrently, the Fourth Nuclear Congress is also being held in the Amphitheatre. Sponsored by more than 30 organizations representing over 350,000 engineers, scientists, technicians, and top management executives, the Nuclear Congress will present a program at which more than 150 scientific and technical papers are to be read on new disclosures and basic discoveries in applying nuclear energy to industry.

Members and guests registered for the scientific meetings conducted by the Nuclear Congress will be admitted to the Atom Fair at no extra cost. The Atom Fair will also be open, at a registration fee of $2.00 per person, to science-minded people from business and industry who are interested in the potentialities of atomic energy as a source of new products, improved quality control, new manufacturing methods, and new sales outlets for their own business.

Among the most impressive exhibits at the Atom Fair will be the nuclear reactors. These will be shown in various sizes and designs. At least two reactors will be actual operating units. One is the portable package nuclear power plant developed for the Army by ACF industries, the other is a student training reactor.

The Atomic Industrial Forum, sponsorer of the Atom Fair, is a nonprofit membership association of more than 500 industrial firms and research and service organizations, labor groups, and educational institutions engaged in the development and utilization of Nuclear energy for constructive purposes.

THE THIRD REACTIVE METALS CONFERENCE and EXHIBIT

Statler-Hilton Hotel, Buffalo, N. Y.

May 27, 28, and 29, 1958

Sponsored by

The Niagara Frontier Section of The Metallurgical Society of AIME

CONDENSED PROGRAM

Monday, May 26, 1958

7:00 pm	Registration Exhibit Open	Mezzanine Show Room

Tuesday, May 27, 1958

Golden Ballroom

8:30 am	Registration
9:00 am	Welcoming Address
9:15 am	Keynote Speaker, D. J. McPherson, Armour Research
10:00 am	Properties and Applications—Titanium Alloys
2:00 pm	Consolidation—Melting and Refining

Washington-Los Angeles Rooms

10:00 am	Consolidation—Powder Techniques
2:00 pm	Physical Metallurgy—Temperature Effects
6:15 pm	Fellowship Hour
7:00 pm	Dinner and Speaker

Wednesday, May 28, 1958

Golden Ballroom

9:00 am	Physical Metallurgy—Phase Relationships
2:00 pm	Physical Metallurgy—Interstitial Effects
Evening	Round Table Discussion, Dr. Bruce W. Gonser, *Moderator*

Washington-Los Angeles Rooms

9:00 am	Properties and Applications—Nuclear
2:00 pm	Metal Processing and Fabrication

Thursday, May 29, 1958

Leaving Statler-Hilton Hotel

9:00 am	Inspection Trip to Carborundum Metals Co. Plant, Akron, N. Y.

Exhibition will be open during entire Conference

Registration Fees for Technical Sessions:

Members of AIME—$7.50 Non-Members—$10.00

New EJC President

On Jan. 10, 1958, Enoch R. Needles, prominent consulting engineer and former President of ASCE, was installed as President of Engineers Joint Council, the unity organization of the engineering profession. When he took office at the Board of Directors meeting, Mr. Needles made four points, summing up the present situation as it relates to engineering and science.

He stated that "The United States is challenged now as a world power because of misdirection of its technological program, not because of the lack of the present technological capability."

Engineers Joint Council is a Federation of 17 major national and regional engineering societies representing more than 250,000 of the nation's engineers.

REACTIVE METALS PROCEEDINGS

(IMD Special Report Series No. 5)

All the Papers at the 1956 Regional Conference
Sponsored by the Niagara Frontier Section, AIME
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INSTITUTE OF METALS DIVISION

THE METALLURGICAL SOCIETY

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Preliminary Report on the Properties of Sodium-Reduced Titanium — by C. M. Brown, R. L. Folkman, and M. Schussler

Fabrication and Application (I)
Mill Processing of Titanium and Titanium Alloys — by L. S. Busch
Aircraft Fabrication of Commercially Pure Titanium — by A. E. Leach and G. F. Kappelt
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General Metallurgy of Reactive Metals
Reactive Metals in Canada — by W. K. Buck
The Properties and Applications of Rhenium — by C. T. Sims and R. I. Jaffee
Some Salient Properties of Zirconium — by R. V. Hilkert
The Metallurgy of Vanadium and Its Alloys — by W. Rostoker

Fabrication and Application (II)
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Metallurgical Characteristics of Tantalum and Their Relationship to the Fabrication of Tantalum Products — by R. W. Yancey
The Extrusion of Zirconium — by P. Lowenstein

Research (I)
Zone Purification of Reactive Metals — by R. L. Smith and J. L. Rutherford
Observations on the Mechanical Properties of Hydrogenated Vanadium — by B. W. Roberts and H. C. Rogers
The Scaling of Columbium in Air — by H. Inouye
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Heat-Treatment and Mechanical Properties of Ti-Mo Alloys — by F. C. Holden, H. R. Ogden, and R. I. Jaffee
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In Step in the United States

The Need

Today, all of India's industry is expanding. The task of industrialization undertaken through this country's *Second Five Year Plan* is an enormous one. With steel basic to the Program's success, the Government of India is financing three new steel plants with a combined capacity of 3 million tons. To this end the country is faced with an urgent need of trained technicians with skill and experience to serve in vital supervisory capacities.

The major goal of India's future expanding industry—industrial leadership—is now being fulfilled through essential on-the-job training and study in U. S. steel mills and educational institutions. This cooperative project to further new India's ambitious industrialization is called the *Indian Steel Training and Educational Program*, whose initials form the words *IN STEP*.

The Program

IN STEP was made possible by a Ford Foundation grant of $1,500,000 to the Government of India. The program calls for a year's training for 200 engineers in a weekly schedule consisting of one day studying in the class-rooms of a university and four days observing and working in a steel plant.

The program is administered by Carnegie Institute of Technology, in cooperation with the U. S. Department of State, the Government of India, and the American Iron and Steel Institute.

Students are assigned to one of five institutions where lodging, classroom instruction, and social life are provided. All of them are English speaking graduate engineers which were hand-picked by the Indian Government and guaranteed jobs upon return. They have pledged to work at least a minimum of five years in the Indian steel industry.

Program In Operation

The key to the training program in steel is the actual in-plant work itself. This has been provided by the full support of seven cooperating American steel companies. Working a full eight-hour shift, the in-plant instruction for each engineer consists of general observation of all steel-making processes. But essentially each student is engaged in specific operations preparing him for the job he will assume when he returns to his country.

The Indian trainees, however, are merely observing and studying American methods, they are not doing productive work, do not replace American workers, and are not receiving wages. The Ford Foundation is paying the cost of their training and of their stay in America.

Participating Companies

For example, Weirton Steel Co., a Division of National Steel Co. at Weirton, Va., is one of seven American steel companies that have agreed to provide on-the-job training for the Indian engineers. Fifteen of the graduate engineers arrived in Weirton on Dec. 2, 1957. Their first week there was spent in an orientation program conducted by the Education and Training Department of the steel company. This was highlighted by tours of the city, the mills, and nearby communities. The second week began the training in their assigned departments in the mills.

All of the trainees at Weirton Steel have engineering or science degrees from Indian universities, and all of them speak, read, and write English. Their ages range from 23 to 30 years. Prior to their arrival in the United States, the Indian engineers were briefed on American institutions. At the Tata Iron and Steel Works, in Jamshedpur, India's largest steel plant, they absorbed two weeks of observation in all phases of steelmaking, and were assigned to a specific plant department for a month.

The program at Weirton is designed to give the trainees a broad understanding of steelmaking facilities and processes. The Indian engineers are spending four days in Weirton and the balance of the week in Pittsburgh at the Carnegie Institute of Technology.

Other Steel companies participating in the *IN STEP* Program are: Bethlehem Steel Co., Inland Steel Co., Jones & Laughlin Steel Co., United States Steel Corp., Youngstown Sheet and Tube Co., and Republic Steel Corp.

These seven companies which provide the observation and work in the steel mills, have also assumed the costs relating to the in-plant instruction of trainees, including costs of developing training materials and providing managerial time for instruction.

Education

Classroom work for the engineers has been provided by five associated universities, where the trainees are living and dining with other young men of similar status. Each college has appointed a faculty advisor for them, whose responsibility is their education and welfare.

The academic work of the young engineers primarily consists of the various processes of steelmaking, involving 38 technical subjects from the forging of axels to the production of stainless steels. Beyond that, they are studying the American scene, with the iron and steel industry as an example of its economic development and are getting a first-hand understanding of the American way of life.

Universities participating in the educational program are Carnegie Institute of Technology, Pittsburgh; Case Institute of Technology, Cleveland; Illinois Institute of Technology, Chicago; Lehigh University, Bethlehem, Pa.; and Youngstown, University, Youngstown, Ohio.

International Relations

Civic groups of all description, men's and women's clubs and chambers of commerce have planned events for the visitors in order that they might feel that they are not merely students in the United States, but are part of an American community.

A warm example of the hospitality and friendliness which has stimulated better understanding between the Indian engineers and their American benefactors, was recently expressed when the Pittsburgh Section of The Metallurgical Society of AIME played hosts to 42 of the young engineers at the Section's Off-the-Record Meeting in November, at the Penn-Sheraton Hotel, Pittsburgh.

On Jan. 25, 1958, India's Republic Day, 40 of the graduate engineers feted 200 citizens of Bethlehem, Pa., as part of their Indian Republic celebration. They planned and personally financed the commemoration of this national holiday of India, one of their most important, akin to our fourth of July observance.

The students, who are studying at Lehigh University and the Bethlehem Steel Co., entertained their teachers and instructors at VanBittner Union Hall with a native menu and a program of classical and light music of India. A highlight of this program was an original number, written and presented by a quartet of the visiting students, entitled *Our Life in Bethlehem, Pa.*

Conclusion

Steel is basic to new India's plan for further industrial growth. The *Second Five-Year Plan*, now underway, will expand the annual productive capacity of India's steel industry from 1,600,000 tons to 5,600,000 tons. A third Five-Year program, already planned calls for further steel expansion to 18,000,000 tons a year.

Since the current steel expansion program will require an increase of 2200 in supervisory personnel, and it is impossible to train such a large group in India, other countries were

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In Step

(*Continued from page 205*)

asked to lend a hand in the task. The United States, in an effort to spur the fulfilling of this urgent need, is training 200 of these key men in U.S. steel plants. Thus American private industry, philanthropy, and education are cooperatively insuring potential Indian industrial leaders with an invaluable practical training as well as fostering better Indian-American relations.

40th National Metal Exposition To Be Held

The 40th National Metal Exposition and Congress is scheduled for the week of Oct. 27 to 31, 1958, at the Cleveland Public Auditorium, Lakeside and East 6th Street, Cleveland.

Exhibit hours will be as follows: Monday, Oct 27 to Wednesday, Oct. 29, from 12:00 noon to 10:30 p.m.; and Thursday, Oct. 30 to Friday, Oct. 31, from 10:30 a.m. to 6:00 p.m.

AIME members are advised that their AIME registration badge will admit them to the exhibit at no extra charge.

Atoms for Peace Project at Argonne

A gathering of nearly 70 scientists and engineers from throughout the free world began a semester of classroom and laboratory training on February 4th, at the sixth session of the International School of Nuclear Science and Engineering at Argonne National Laboratory, Lemont, Ill.

Their training program, a continuing part of President Eisenhower's *Atoms for Peace* project, is being conducted by the U. S. Atomic Energy Commission. Most of the scientists and engineers already have completed a semester of studies at either North Carolina State College, Raleigh, N. C., or Pennsylvania State University, State College, Pa.

Nuclear reactors, their design, construction, instrumentation, and use, are the principal subjects of the unclassified course. Sixth session enrollment has brought the number to more than 350 of scientists and engineers who have received International School training. As the session began, a new group of scientists and engineers started to train at the two cooperating universities. They will come to Argonne in June 1958.

Enrollment for the sixth session totals 55 scientists and engineers from 22 foreign countries and 11 from the United States. Most of the American participants are sponsored by private firms interested in nuclear energy. Foreign participants were largely selected by atomic energy commissions in their home countries, although some come from universities and industry.

International School training at Argonne is divided into two periods. Following six weeks of formal instruction, the scientists and engineers spend the remainder of their time at the Laboratory conducting individual research projects. Though primarily concerned with nuclear reactors, the Argonne course includes other areas of study also important in the putting to use of nuclear energy for peaceful purposes.

The laboratory work performed includes procedures which are basic to the entire reactor technology for large-scale experiments in reactor engineering and in preparation and reprocessing of reactor fuel. Opportunity is available for those who wish training in the techniques of nuclear research in nuclear chemistry and physics, and in nuclear engineering.

The Nation's senior atomic energy research facility, Argonne National Laboratory is located on a 3,700 acre tract of land approximately 25 miles west of Chicago. It is a center of research for all phases of science relating to peaceful uses of atomic energy. Approximately 2,900 scientists, engineers, technicians, and other employees work at the Laboratory.

Air Force Sponsors Research Program in Physical Metallurgy

An active research program in physical metallurgy is currently under way in the department of metallurgical engineering, Stanford University, Stanford, Calif. As part of this program, the U. S. Air Force's Office of Scientific Research is sponsoring a study of the effect of solute elements on the mechanical behavior of grain boundaries in high purity aluminum at very high temperatures.

For this work, techniques have been developed by which large bicrystal slabs of high purity aluminum and aluminum alloys are grown from the molten liquid phase. These bicrystals, set up to a foot long, are formed so that a single straight grain boundary runs along the longitudinal axis. The crystallographic orientation of each of the component crystals with respect to the grain boundary, as well as to each other, can be accurately controlled.

The bicrystals are used as follows: A very fine grid is scratched on samples which are cut from the bicrystals. The samples are then tested either at a constant strain rate or under constant stress, in a high temperature furnace which has a small window in the hot zone. Microscopic observation and measurements can then be made through the window, and the strain at the bicrystal boundary, as well as the deformation in each of the component crystals, can be determined.

It has been found that deformation sometimes causes the boundary between the bicrystals to migrate in a direction perpendicular to its plane as well as sliding in its own plane. Correlation of these data with information obtained by concurrent measurements of the overall stress and strain has enabled accurate information to be obtained on the kinematics of crystallographic orientation and solute content.

Women's Technical Writing Program

Young women may seek unique opportunities associated with engineering and science by considering a new curriculum in technical writing and editing recently offered by Carnegie Institute of Technology, Pittsburgh.

This program was unveiled for the first time at the First Annual Institute for Technical Writers held recently on the Carnegie campus. It is aimed at increasing the nation's supply of trained technical people by preparing women to relieve for more important duties, the scientists and engineers who must spend excessive amounts of time preparing reports, manuals, and other written interpretations of their work. It will also enable women to seek jobs in manufacturing and engineering companies in the growing public relations, advertising, and sales promotion fields.

The first of its kind to be held in the Pittsburgh area, the new four-year program will be an option in the Department of General Studies of Margaret Morrison Carnegie College for Women. It will consist largely of work in three main areas. These are: basic science and mathematics; English language, writing, and literature; and social sciences and the arts, with additional courses in graphic arts processes, layout and design, typewriting, and technical research and report writing. The latter will be a newly-created course, with others already existing in the programs of Carnegie's various schools.

MISTAKEN IDENTITY

The paper, *Determination of Tests for Hydrogen Embrittlement of Titanium Alloys*, presented at a Institute of Metals Division technical session during the AIME Annual Meeting, was incorrectly ascribed to **R. R. Kennedy** as author. The author should have been listed as **A. H. Fleitman**, Crane Company.

AROUND THE SECTIONS

More than fifty metallurgists visited Federal Telecommunication Laboratories, Nutley, N. J. on January 16, for an informal briefing on the latest applications of metals in the field of electronics. This occasion was the highlight of the regular monthly meeting of the **Physical Metallurgy Group** of the **New York Section,** and was attended by Robert W. Shearman, Secretary-Treasurer of the Metallurgical Society of AIME. The group was welcomed to the laboratories, a division of the International Telephone and Telegraph Corp., by FTL president Henri G. Busignies. Following a visit to the company's 300-ft microwave research tower, the guests were taken on an afternoon lecture-tour of FTL's Physical-Chemical Laboratory. The field trip concluded with a social hour and dinner in the company's clubhouse, and a lecture by Robert M. Fisher, of the United States Steel Corp.'s research center, Monroeville, Pa. He discussed *Applications of Electron Optics in Metallurgical Research.*

• The March 24, meeting of the **Physical Metallurgical Group** of the **New York Section,** will be held at the Research Center of the American Brake Shoe Co., Mahwah, N. J., hosts to the group. The meeting will start with a visit of the research center in the afternoon, spent in touring the laboratory and participating in a few short meetings with the personnel of the research center.

A social hour and dinner will follow the field trip, with the lecture in the evening. Dr. Arthur S. Nowick, of the IBM Watson Laboratory, will address the group on *Internal Friction in Alloys.* He joined IBM in 1957 and has organized a group there to carry out basic research in the field of lattice imperfections in metals. He has published several papers in this field, and his talk will discuss the most recent experiments on the Zener Peak in substitutional solid solutions, which have led to new concepts in its interpretation. He will also describe an internal friction study of precipitation in the alloy Al-4 pct Cu.

The **St. Louis Section** held a dinner-meeting on January 10, at the York Hotel, St. Louis. R. M. Edwards, superintendent of development and research, Mallinckrodt Chemical Works, Uranium Div., was the featured speaker. He spoke on the general processes used in the reduction and purification of uranium salts received from the Colorado Plateau, Canadian and South African uranium mills. Samples of the purified uranium salts (black, yellow, and green) were displayed as well as a small ingot of uranium metal. Norton E. Berry, technical director, Mallinckrodt Chemical Works, Uranium Div., who originally planned to speak to the group, was ill and unable to attend.

At a recent meeting of the **Upper Peninsula Section** held at Ishpeming, Mich., new officers were elected. They are: chairman, Victor E. Kral, resident manager of Northern Mining Section, Ford Motor Co.; vice chairman, John C. Wangaard, superintendent of the Cory Mine Pickands Mather Co.; and secretary-treasurer, Roy W. Drier, professor, Michigan College of Mining and Technology. Grover J. Holt, AIME President, was a guest at the meeting.

In an address to the **Nevada Section** at the Fremont Hotel, Las Vegas, John C. Kinnear, general manager of Kennecott Copper Corp.'s McGill mines in White Pine county, announced that a huge skip haulage system which will cost approximately $1,500,000 is being installed by Kennecott Copper Corp. at Liberty Pit. Kinnear spoke to 150 persons at the meeting and explained mining operations at the Kennecott installations at McGill. During the meeting, F. A. Lawrence was installed as 1958 chairman of the Section. Lawrence, of McGill, is chief chemist and research engineer for Kennecott in Nevada.

Physical Metallurgists Visit Federal Telecommunication Laboratories

The Physical Metallurgy Group of the New York Section, AIME, visited the Federal Telecommunication Laboratories, a Division of International Telephone and Telegraph Corp. on January 15. After a tour of the laboratories and dinner, served at the Federal Telecommunications Dining Room, a talk was presented on *Applications of Electron Optics in Metallurgical Research,* by Dr. Robert M. Fisher of the United States Steel Corp. Research Center, Monroeville, Pa.

The Physical Metallurgy Group was welcomed to Federal Telecommunication Laboratories by Mr. H. Busignies, President. He explained the telecommunications work performed at the laboratories, stressing their experimental work on air navigation systems, over-the-horizon microwave systems for long-distance television broadcasting, and improvement of the telephone in wire communication.

These advances among the many pioneered by Federal Telecommunication Laboratories, depend to a great degree upon the components turned out by engineers and scientists in the IT&T research center's Physical-Chemical Laboratory and seven other labs—Electron Tube, Radio Navigation, Guided Missiles, Electronic Countermeasures, Electronic Systems, Radio Communication, and Wire Communication.

A discussion of the background of the Physical Chemical Laboratory was given by Frederich A. Muller, Director. He explained the increasing use of metallurgy in electronics for the development of new components.

Guided tours were then made to see the growing of ferrite single crystals by the Verneuil Process, a demonstration of infra-red polariscope and test equipment for the measurement of life time and resistivity in silicon, electronic spectroanalysis, and a demonstration of corona measurement on high-voltage pulse cable.

Federal Telecommunication Laboratories is one of the Nation's leaders in the development of new electronic systems and components for private industry and the military.

Work is carried on in their plant in Nutley, N. J., and a modern new building in San Fernando, Calif. The Nutley installation occupies a 100-acre tract, and includes two buildings and a 300-foot aluminum-sheathed tower, used chiefly for microwave experimentation.

News of EDUCATION

► The National Science Foundation recently announced that it is accepting proposals from universities and colleges interested in sponsoring In-Service Institutes for secondary school teachers of science and mathematics to be held during the academic year 1958 to 1959.

A primary purpose of the In-Service Institute program is to assist colleges and universities in their efforts to encourage teachers in outlying school districts to take advantage of scientific training facilities not otherwise readily accessible to them. The Foundation has already announced support of 125 summer and academic-year institutes in colleges and universities throughout the Nation during the summer of 1958 and the following school year.

Foundation support to some 25 In-Service Institutes will cover all tuition and fees, plus any other direct costs to the college or university directly attributable to the program. Though the Foundation does not provide stipend support for participants

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Education

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in the all in-service program, the NSF grants provide funds to underwrite travel expenses in connection with attendance at the Institutes.

Deadline for submission of completed proposals to the Foundation is March 15, 1958. Directions for preparing proposals may be obtained from the *Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D. C.*

► The Gordon Research Conferences for 1958 will be held from June 9 to August 29. Locations of the Conferences are as follows: *Solid State Studies in Ceramics*, Kimball Union Academy, Meriden, N. H.; *Corrosion*, Colby Junior College, New London, N. H.; and *Physical Metallurgy*, New Hampton School, New Hampton, N. H.

The Conferences were established to stimulate research in universities, research foundations and industrial laboratories. This purpose is achieved by an informal type of meeting consisting of scheduled lectures and free discussion groups. Meetings will be held in the morning and evening, Monday through Friday, with the exception of Friday evening. The afternoons are available for participation in discussion groups as the individual desires.

In order to protect individual rights and to promote discussion, it is an established rule of each Conference that all information presented is not to be used without specific authorization of the individual making the contribution, whether in formal presentation or in discussion. No publications are prepared as emanating from the Conferences.

Requests for attendance at the Conferences or for any additional information, should be addressed to *W. George Parks, Director, Department of Chemistry, University of Rhode Island, Kingston, R. I.* From June 9th to August 29th, mail should be addressed to *Colby Junior College, New London, N. H.* Each applicant must state the institution or company with which he is connected and the type of work in which he is most interested. Attendance at each Conference is limited to 100 persons.

The complete program of the Conference was published in *Science* for February 28th.

► Closely allied with today's emphasis on research and development of rockets and guided missiles is the subject matter of the Pennsylvania State University's Short Course on Materials Engineering Design for High Temperature, which will be held June 29 to July 3, 1958 on the Penn State campus.

Other applications of materials used at high temperatures include gas and steam turbines, aircraft engines, components of nuclear energy, and equipment used in the petroleum and chemical industries.

The course will include metallurgical properties, mechanical static properties at high temperatures, thermal shock and fatigue properties, and design for high temperatures. Lectures will also be given by a number of prominent engineers and scientists in the field.

Further details on this course may be obtained from *Joseph Marin, Department of Engineering Mechanics, The Pennsylvania State University, University Park, Pa.*

Penn State University is also offering a short course on Mechanical Properties of Materials. Intended to keep design engineers and others engaged in research on materials abreast of new developments in the field, the course will be conducted from July 7 to 11, 1958.

Subjects to be covered will include hardness of metals, plastic behavior of metals under simple and combined stress, creep resistance and high temperature properties of metals, fatigue strength of metals, effects of radiation on metals, recent developments in testing machines and instrumentation, and metals under high speed loading. Lectures will also be given by a number of engineers and scientists in the field.

Further information may be obtained by contacting *L. W. Hu or Joseph Marin, Department of Engineering Mechanics, The Pennsylvania State University, University Park, Pa.*

► Eugene G. Grace, honorary chairman of the Bethlehem Steel Co., was recently praised upon his retirement, for four and a half decades of service to Lehigh University, Bethlehem, Pa., in the annual president's report of the University.

Mr. Grace was elected a member of the University's Board in 1912, at the age of 36, and in 1924 was named President of the Board.

► The Atomic Energy Commission recently announced the approval of grants totalling $3,499,638 to 55 American colleges and universities to be used to expand training facilities for increasing numbers of nuclear scientists and engineers.

This brings to $6,764,388 the total amount for 91 training grants made by the Commission during the past ten months, to 68 educational institutions.

The grants are part of the Commission's assistance program to encourage colleges and universities to establish curricula or to broaden already established study programs for the purpose of easing the shortage of trained manpower in the atomic energy field. The funds will be applied toward the purchase of laboratory equipment.

More than 100 applications have been received since the program was inaugurated. Some proposals, received too late for evaluation prior to this third round announcement, are under study.

The grants announced provide for small training reactors at seven educational institutions: University of Arizona, University of California at Los Angeles, University of Delaware, University of Missouri School of Mines and Metallurgy, Ohio State University, Oregon State College, and University of Wyoming. Each of the institutions will be required to obtain licenses to operate the reactors.

Grants for the purchase of construction of nuclear reactors for science and engineering education are made only to colleges or universities which conduct studies in nuclear technology at the graduate level and are accredited by the Engineers' Council for Professional Development.

In addition to grants, the Commission has made loans of nuclear materials, such as uranium metal to furnish fuel for the reactors, and neutron sources to colleges and universities. This includes furnishing fuel elements for research reactors and subcritical assemblies without charge.

The Commission also supports fellowships, finances research projects at colleges and universities, and operates a number of training programs in nuclear technology for students and teachers.

► A research program to investigate the patterns of creativity in the sciences has been established by New York University's Division of General Education. Directed by Adjunct Professor Myron A. Coler, the new creative science program will be concerned with the recognition and encouragement of scientific talent.

One of the first projects of the program will be a series of seminars to begin at NYU early in 1958. Plans to publish the findings of the seminars are also being made. The participants will be research workers and research managers from government, industry, and the University. Using an operational approach, they will seek to arrive at ways of dealing with creativity, to delineate creative research patterns, and to foster interscience research projects. The subject of the first seminar will be *The Role of Conjecture.*

Participation in this series will be by invitation, but according to Dr. Coler, interested persons should feel free to write to or phone him at NYU's Division of General Education, Washington Square, New York City.

Another project of the Creative Science program will be the establishment of a specialized reference library to collect and codify the extensive but scattered literature pertinent to creativity in the sciences. Annotated bibliographical literature material will also be published.

PERSONALS

Raymond T. Whitzel has retired as vice president and general production manager of the Aluminum Co. of America, Pittsburgh, following more than 42 years of service in the company. During his Alcoa career, Mr. Whitzel achieved a number of patented improvements in aluminum manufacturing processes, and distinguished himself in plant organizational responsibilities. **Harold C. Erskine,** Alcoa's assistant general production manager, has been appointed general manager in charge of the company's smelting and fabricating operations.

H. A. Pearse has resigned his post from Howe Sound Co., New York, N.Y., as vice president in charge of metallurgy and construction. He is now engaging in private consulting work in the metallurgical field.

The Universal-Cyclops Steel Corp., Bridgeville, Pa., has announced the election of **Richard C. Diehl** as vice president of operations. He was formerly president of the Chase Brass and Copper Co.

James H. Moore has been named general manager of NCR Equipment Corp., Newton, Mass. He will be responsible for development, production and sales of high vacuum equipment manufactured at the NCR Equipment plant in Newton, Mass. Moore was formerly the first general manager of Vacuum Metals Corp., Division of Crucible Steel Co. of America, Syracuse, N. Y.

Seven important changes were recently announced in the sales and operating personnel of American Smelting & Refining Co.'s Federated Metals Div. **Aubrey M. Callis** has been appointed general sales manager, replacing **Edgar L. Newhouse III,** who has been named Washington, D. C. representative for the company. **C. J. Williamson,** who has been Washington, D. C. representative, has become a consultant for the company. **John L. Griffith** has become sales manager of Federated's Eastern Div. **E. J. Baker,** manager of the Rochester, New York, Federated Sales Office, is replacing Robert A. Colton as assistant sales manager of the Eastern Div. **J. L. Kammermeyer** has left his post as manager of the Houston Plant, and is now general sales manager of the new Central Aluminum Dept. **R. A. Colton** has replaced Mr. Kammermeyer as manager at Houston.

Donald J. McPherson has been appointed manager of the metals research dept. at Armour Research Foundation of Illinois Institute of Technology, Chicago. McPherson was previously manager of the metals dept.

J. Ray Coulter was promoted to manager of manufacturing of the American Cyanamid Co.'s industrial chemical div., New York City. He was formerly manager of manufacturing for the phosphates and nitrogen div. In his new position, Coulter will be responsible for the supervision of manufacturing activities of the division's 15 plants.

William C. Wright has been appointed to the position of production manager for SKF Industries Inc., Philadelphia. He previously was manager of the company's Altoona, Pa. plant since its inception.

The appointments of **Albert P. Gagnebin and L. E. Grubb** as assistant vice presidents of The International Nickel Co. Inc. were recently announced by the company. Mr. Gagnebin is continuing as manager of Nickel Sales Dept., New York, and Mr. Grubb, who has been general superintendent of the Company's Huntington, W. Va. Works, has transferred to the New York office.

Vinton H. Clarke, previously vice president in charge of mining and exploration of Howe Sound Co., New York, N.Y., has now joined Behre, Dolbear & Co. Inc., New York City. Clarke was associated with Howe Sound Co. for over 20 years.

Harry H. Kessler and **Victor M. Onet** were recently elected to the board of directors of Chromalloy Corp., White Plains, N. Y. Kessler is president and a director of the Sorbo-Mat Process Co., St. Louis, and the Sorbo Cast Corp., and also heads the metallurgical consulting firm of Harry H. Kessler and Assoc.'s and the Foundry Design Co. Onet is a vice president of General Builders Supply Corp.

George P. Hansen, assistant vice president in charge of steel plants of Wheeling Steel Corp., Wheeling, W. Va., has recently retired. Hansen has been associated with Wheeling Steel since 1941, when he was appointed general manager of the Bentwood (W. Va.) Works. He has been in his present capacity since 1944.

P. D. Deeley has been appointed a sales engineer for Electro Metallurgical Co., Div. of Union Carbide Corp. at Pittsburgh.

B. D. Thomas has been named to the presidency of Battelle Memorial Institute, Columbus, Ohio, succeeding Clyde Williams, a former AIME President, who recently retired. Thomas joined the staff of Battelle in 1934 and was appointed vice president of the Institute in 1955.

G. E. Smith has been promoted to sales engineer for Electro Metallurgical Co., Div. of Union Carbide Corp., Pittsburgh. He was formerly sales engineer for the company in New York.

E. George Hartmann, previously general product manager of the Wire and Cold Rolled Products Div. of the Roebling Corp., a subsidiary of The Colorado Fuel and Iron Corp., has been elected vice president—sales of John A. Roebling's Sons Corp. He is now located at the Corp.'s main office in Trenton, N. J.

Eugene G. Grace, for 12 years chairman of Bethlehem Steel Corp., has recently retired. He served as chairman of the Steel Corp. since 1945. Now honorary chairman, Mr. Grace will continue as director.

Alvin P. Scheel has been appointed to the position of general superintendent of the Fairless Works of the National Tube Div. of U. S. Steel Corp.

Cyril S. Smith, leader in metallurgical research, recently spoke on the *Microstructure of Metals and Other Polycrystalline Bodies* at the Mellon Institute auditorium, Pittsburgh.

Walter Burd, who is employed as a metallurgist for Carpenter Steel Co., was recently honored by the AIME Philadelphia Section. The Section presented him with a medal, a certificate, and a cash award, for an outstanding paper on metallurgy by a Drexal student. The title of his paper was *The Effects of External Compressive Stresses on the Isothermal Decomposition of Austenite.*

James A. Maggetti has been named assistant plant manager of Kaiser Steel Corp.'s Napa, Calif. plant. He is also continuing as general manager of the company's Fabricating Div. plants at Napa and Fontana, Calif.

Frederick W. Fink, formerly assistant chief of the Corrosion Research Div., Battelle Memorial Institute, Columbus, Ohio, has recently become chief of that division.

James Chisholm, previously assistant superintendent, blast furnace, U. S. Steel Corp., Fairless Works, Fairless Hills, Pa., is now working as superintendent, central furnaces and docks, American Steel and Wire Div., U. S. Steel Corp., Cleveland.

James D. Moore, formerly chief process engineer for Vitro Uranium Co., Salt Lake City, has been promoted to production manager of the company.

(*Continued on page 210*)

Personals

(Continued from page 209)

S. J. Cort, vice president in charge of steel operations, Bethlehem Steel Co., Bethlehem, Pa., has retired. He is succeeded by **E. F. Martin,** formerly general manager of the company's Lackawanna, N. Y. plant.

Richard F. Schaffer has been appointed to chief metallurgist for the Denver Div. of the Gardner-Denver Co., Quincy, Ill.

Joel H. Morris, who served as chief engineer for F. H. McGraw & Co., New York, has been named to assistant to the president of that firm. He is taking over the additional administrative duties in the engineering dept. as well as other phases of the company's operations.

Laurence D. Pellier has been appointed applications chemist by the Norecol Instruments Div., Philips Electronics Inc., Mt. Vernon, N. Y. Mrs. Pellier will devote her attention to technical problems involving electron microscope techniques. She formerly was a research metallurgist for Sigmund Cohn Corp., Mt. Vernon, N. Y.

Robert A. Woofter has been promoted to metallurgical contact engineer for Jones & Laughlin Steel Corp., Pittsburgh. Prior to his advancement, Woofter was coating and corrosion research supervisor for the company. He will be concerned with providing field technical service on tin mill products in J&L's technical services div.

Robert R. Titus has been elected to the board of directors of Alan Wood Steel Co., Conshohocken, Pa.

James M. Mathews, formerly product manager, silicon electric steel sales for Allegheny Ludlum Steel Corp., Pittsburgh, has been appointed director of sales, magnetic and electronic materials for the company.

Edward Epremian has joined the technical staff of the Metals Research Laboratories, the Electro Metallurgical Co., Division of Union Carbide Corp., Niagara Falls, N. Y.

Ben R. Badeusz, previously assistant to the vice president in charge of manufacturing at Great Lakes Plating, Chicago, is the newly appointed sales representative in the greater Chicago area for Wagner Brothers Inc., Detroit.

C. T. Stott, previously an assistant general manager of Bethlehem Steel's Sparrows Point plant since 1953, has been promoted to general manager of the plant. Mr. Stott, who has spent his entire career at the Sparrows Point plant, succeeded C. E. Clarke, who retired.

C. W. Sherman, formerly with Latrobe Steel Co., Latrobe, Pa., is now with Jones & Laughlin Steel Corp., Pittsburgh.

Stanley T. Wallage has retired after 35 years of service with the American Smelting and Refining Co. in Texas. For the last 15 years he has been at the company's Corpus Cristi, Texas plant in the position of department superintendent in charge of leaching, filtration, purification and cadmium product sections.

Andrew F. Kravic, previously an instructor in metallurgical engineering at the Polytechnic Institute of Brooklyn, N. Y., is now associated with the nickel sales dept. of the International Nickel Co., New York. **Everett Sarratt** has been appointed chief engineer, instrument products, for Tracerlab Inc., Waltham, Mass. He formerly was chief engineer of the marine div. of McKay Radio at Clark, N. J.

Colin Forbes, who has held the position of superintendent of the Simplex Div. at the Marietta, Ohio plant of Electro Metallurgical Co., has been transferred to the company's Niagara Falls, N. Y. plant.

Walter W. Finke, president of the Datamatic Div. of Minneapolis-Honeywell Regulator Co., Newton Highlands, Minn., has been elected a vice president of the corporation.

John F. Donnelly, formerly process representative of Air Product Sales Co. and supervisor of welding instruction and production, Eastern Aircraft Div. of General Motors, is now director of technical sales training of All-State Welding Alloys Co. Inc., White Plains, N. Y.

J. A. Schroeder has been appointed district manager in charge of the new Cleveland office of Fairmont Aluminum Co., a wholly owned subsidiary of Cerro de Pasco Corp., New York.

Ernst M. Goldstein has resigned from his position as group leader with the Nickel Processing Corp., Montclair, N. J., and has joined the Metallurgical Research Dept. of Metal and Thermit Corp., Rahway, N. J.

F. Morton Leonard, chief of the metals div. of the United States Tariff Commission for the past 34 years, has retired after 36 years of military and civil service with the United States Government. The commission presented Mr. Leonard with a pin and a certificate in recognition of his 35 years of federal service.

Percy H. Botster, head technical advisor to the metallurgical div., U.S. Bureau of Mines, Washington, D. C., was recently honored at a Pittsburgh luncheon for outstanding scientific and engineering contributions to modern iron and steel technology. The tribute was paid by the Eastern States Blast Furnace and Coke Oven Assoc., and the Blast Furnace Assoc. of Chicago. These associations presented him with a memorial scroll recounting Mr. Rotster's many accomplishments and the influence he has had on the coke oven and blast furnace industry.

George Sachs, professor of metallurgical engineering and associate director, Syracuse University Research Institute, Syracuse, N. Y., will receive an honorary Doctor of Engineering degree at the May 5, 1958 commencement of the Bergakademie (School of Mines) Clausthal, West Germany. He was selected for the award for his outstanding achievements in the field of science of metals and its practical application.

J. George Miles has been appointed assistant to the vice president of Armco Steel Corp. in charge of the Sheffield div. In his new capacity he will maintain his headquarters in Houston, Texas where he was formerly director of personal (cq) relations for the Sheffield Div.

George E. Morris, superintendent of Chile Exploration Co.'s copper smelter at Chuquicamata, has been named director of metallurgy, The Cananea Consolidated Copper Co., S. A. Mr. Morris will be located at the company's headquarters at Canaea, Sonora, Mexico. Both of these companies are subsidaries of the Anaconda Co.

G. G. Hatch has been appointed president of W. S. Atkins & Associates Ltd., a firm of consulting engineers having offices in Toronto and Montreal, Canada. This company is associated with W. S. Atkins & Partners of London, England. Hatch was previously plant superintendent of the Quebec Iron and Titanium Corp., Sorel, P.Q.

Stuart I. Harris, formerly sales engineer, has been named technical sales assistant serving the Industrial Products Div. of Keasbey & Mattison Co., Ambler, Pa.

William L. Lodding, associate research specialist, Rutgers University, will use an unrestricted grant of $750 which was given to the University by the American Metals Co. Foundation Inc., in support of basic research in the University's Bureau of Mineral Research, New Brunswick, N.J. Lodding is conducting research in the development of differential thermal analysis.

OBITUARIES

Willis R. Whitney (Legion of Honor 1902), eighty-nine, founder of General Electric's research laboratory, died of a heart attack at Ellis Hospital, Schenectady, N. Y. on Jan. 9, 1958.

Born in Jamestown, N. Y., on Aug. 22, 1868, he graduated from Massachusetts Institute of Technology in 1890 and received his doctorate in chemistry from the University of Leipzig, Germany in 1896. He was an MIT faculty member before joining General Electric, and during this time advanced the electrochemical theory of corrosion universally accepted today. Until his death, he was a non-resident professor of chemical research at MIT.

Dr. Whitney founded General Electric's research laboratory in a barn in 1900. He served as director of the laboratory for the next 32 years, from which came scores of electrical, electronic, and industrial developments and inventions. His laboratory contributed to the improvement of the incandescent bulbs, X-ray equipment, radio, radar, television, World War I submarine-detection apparatus, and turbine power. Perhaps most important, Dr. Whitney's work set the pattern for industrial scientific laboratory research work in the United States.

The scientist was honored many times. He received the Willard Gibbs Medal of the American Chemical Society in 1916, the Chandler Medal of Columbia University in 1920, the Franklin Medal in 1931, the Edison Medal in 1935, and the Public Welfare Medal of the National Academy of Sciences in 1938.

Dr. Whitney was made a Chevalier of the Legion of Honor of France in 1937. He was a member of the AIME, the National Academy of Sciences, National Research Council, American Chemical Society, the American Electrochemical Society, American Institute of Electrical Engineers, American Academy of Arts and Sciences, American Physical Society, The Franklin Institute, American Philosophical Society, British Institute of Metals, and the French Legion of Honor.

At the time of his death, Dr. Whitney was an honorary vice president of General Electric. He is survived by his wife, the former Miss Evelyn Jones, whom he married just after graduating from MIT in 1890, and a daughter, Mrs. Evelyn Schermerhorn.

Lawrence C. Flikinger (Member 1948) passed away on July 17, 1957 in Youngstown, Ohio. Born in Columbiana, Ohio on Aug. 21, 1896, was educated at Ohio State University from 1914 to 1917. He was a member of AIME, the American Chemical Society, and the American Society of Metals. At the time of his passing, Mr. Flickinger was employed as chief chemist, Campbell Works, Youngstown Sheet & Tube Co., Youngstown, Ohio.

Tracy V. Stephens (Member 1955) died on April 17, 1957 in Great Falls, Mont. Born in Cadillac, Mich. on Dec. 10, 1917, he studied at Michigan College of Mining and Technology and received his B.S. Ch.E. in 1940. At the time of his death, Mr. Stephens was serving as chief chemist for the Great Falls Reduction Dept., Anaconda Co., Great Falls, Mont.

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NECROLOGY

Date Elected	Name	Date of Death
1905	Edgar C. Agabeg Legion of Honor	Unknown
1935	Charles H. Bowen	Jan. 4, 1958
1948	Lawrence C. Flickinger	July 17, 1957
1951	James D. Francis	Jan. 8, 1958
1952	F. Hewett	Dec. 27, 1957
1916	Charles Hoyle	Dec. 28, 1957
1953	Payton L. Mitchell	Oct. 26, 1957
1955	T. V. Stephens	April 17, 1957
1948	Roy J. Tribbey, Jr.	September 1957
1902	W. R. Whitney Legion of Honor	Jan. 9, 1957

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COMING EVENTS

Mar. 12, AIME New York Section, Powder Metallurgy Group, Brass Rail Restaurant, New York.

Mar. 17-21, EJC Nuclear Congress, International Amphitheatre, Chicago.

Mar. 20, AIME Cleveland Section, regional symposium, Carter Hotel, Cleveland.

Mar. 25, AIME Connecicut Section, dinner-meeting, Chase Country Club, Waterbury, Conn.

Mar. 27-28, AIME San Francisco Section, St. Francis Hotel, San Francisco.

Mar. 27-29, AIME Pacific Southwest Conference, St. Francis Hotel, San Francisco.

April 9, AIME San Francisco Section, Engineers' Club of San Francisco.

Apr. 14-16, AIME, 41st National Open Hearth Steel and Blast Furnace, Coke Oven, and Raw Materials Conference, Hotel Statler, Cleveland.

April 18, 19, 12th Annual New England Regional Conference, General Electric Research Laboratory, Schenectady, N. Y .

April 23, AIME Niagara Frontier Section, joint meeting with local section, Canadian Institute of Mining and Metallurgical Engineers, Royal Connaught Hotel, Hamilton, Ontario.

April 27-30, 1959, International Symposium on the Physical Chemistry of Process Metallurgy, Penn-Sheraton Hotel, Pittsburgh.

May 5-6, AIME, Conference on Properties of High-Strength Steel, Penn-Sheraton Hotel, Pittsburgh.

May 5, 6, AIME High-Temperature Materials Conference, Ambassador Hotel, Los Angeles.

May 12-16, Southwestern Metal Exposition and Congress, State Fair Park, Dallas.

May 27-29, AIME Third Reactive Metals Conference; host section: Niagara Frontier Section; Statler Hotel, Buffalo.

June 6, AIME NOHC Southern Ohio Section, golf outing, Summit Hills Country Club, Fort Mitchell, Ky.

Oct. 3-4, AIME NOHC Southern Ohio Section, fall meeting, Deshler-Hilton Hotel, Columbus, Ohio.

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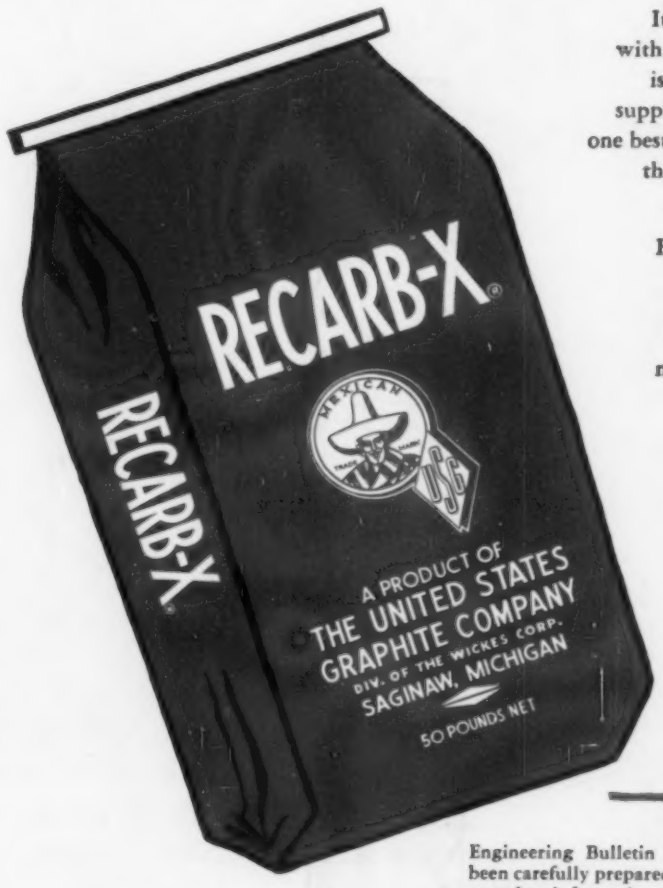

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